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HELDMG: *Heliothis* (Lepidoptera: Noctuidae) Spp. Damage Subroutine for the Cotton Model GOSSYM

ABSTRACT

Thomas, W.M. 1988. HELDMG: Heliothis (Lepidoptera: Noctuidae) Spp. Damage Subroutine for the Cotton Model GOSSYM. U.S. Department of Agriculture, Agricultural Research Service, ARS-72, 59 pp.

An insect damage model (HELDMG), consisting of a command procedure and five subroutines, was written to simulate the within-plant distribution of Heliothis spp. larvae in cotton. Input data were derived from a Heliothis spp. model or from scouting reports. HELDMG can be used with the cotton model GOSSYM to study the effects of Heliothis damage on cotton growth and yield.

KEYWORDS: Cotton damage model, Heliothis spp., subroutine.

CONTENTS

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HELDMG: *Heliothis* (Lepidoptera: Noctuidae) Spp. Damage Subroutine for the Cotton Model GOSSYM

W.M. Thomas

HELDMG is a computer model describing the within-plant distribution of damage caused by *Heliothis* spp. larvae in cotton. It will be added to the cotton model GOSSYM (Baker et al. 1983) as a subroutine and provide a means of integrating a *Heliothis* spp. model with GOSSYM. This integrated model can be used to study the effects of *Heliothis* spp. damage on cotton growth and yield.

HELDMG consists of a command procedure, INMENU, and five subroutines--RDDMG, PREDMG, DAMAGE, REDIST, and FRMTRX. However, when a *Heliothis* spp. model is integrated with GOSSYM, the command procedure and the subroutine RDDMG are not needed. The program is written in FORTRAN and has been run on a VAX 11/750. A general flow chart of HELDMG is shown in figure 1.

COMMAND PROCEDURE INMENU

A command procedure file is included to illustrate how the model uses different types of input data. It is executed at the beginning of the simulation and prompts for *Heliothis* damage data. A choice is required from the following menu:

Input *Heliothis* data
1. *Heliothis* model
2. Scouting report
3. No damage

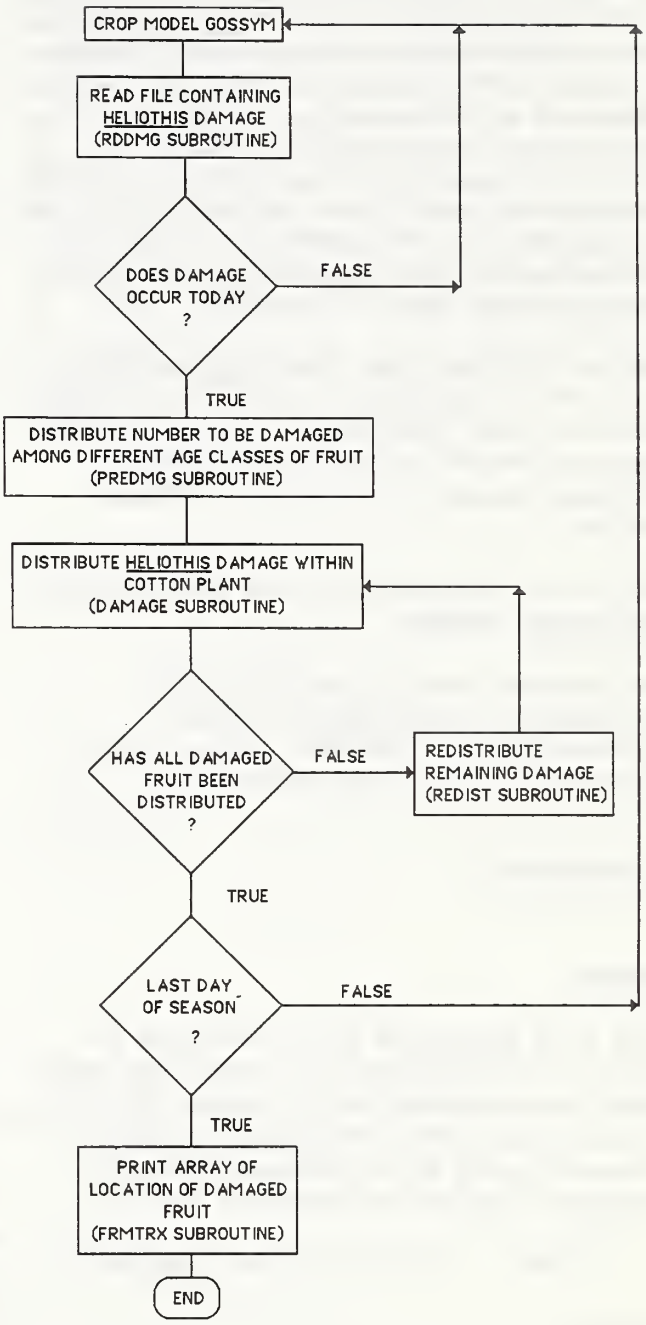

Figure 1
General flow chart of HELDMG.

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This study was conducted by the Agricultural Research Service, USDA, in cooperation with the South Carolina Agricultural Experiment Station.

Option 1: If you use information from a Heliothis model, another menu will be presented. From this second menu you can either (A) enter the number of larvae per acre or (B) enter the number of fruit damaged by small and large larvae. These data are obtained from the Heliothis spp. model MOTHZV (Hartstack and Witz 1983). If you choose option A, then the day of the year of infestation, physiological age of the larva, and the number of larvae per acre must be entered. If you choose option B, then the day of the year of infestation and number of fruit damaged per acre by small larvae and by large larvae must be entered.

Option 2: Data from scouting reports concerning Heliothis damage can also be entered into the model. These data are day of year of infestation, percent damaged squares, and percent damaged bolls.

Option 3: This option runs GOSSYM with no Heliothis damage.

A temporary work file (INPUT.DMG) containing the Heliothis damage information is created. Data in this file are used by the subroutines.

SUBROUTINES

RDDMG

For each simulated day, INPUT.DMG is read. If the number of larvae per acre has been entered, and if damage is to occur today, then the number of fruit damaged today is calculated using an equation derived by Townsend (1973).

$$HZBUG = 0.035 + (0.093 * BUGAGE)$$

where:

HZBUG = number of fruit damaged today
BUGAGE = physiological age of larva

PREDMG

The cotton plant is inventoried, and the fruiting forms are grouped into seven age classes--small, medium, and large squares, flowers, and small, medium, and large bolls.

The number of damaged fruit is distributed among these age classes, depending on the type of input data. If the data are from a Heliothis model, the damage is distributed based on preference and stratification coefficients derived by Wilson and Gutierrez (1980). These coefficients describe the changing preferences of Heliothis larvae for different aged fruits as the age distribution of the larvae and fruit within the cotton plant changes.

$$P_{ij} = A_i S_{ij} C_i / \Sigma(A_i S_{ij} C_{ij})$$

where:

P_{ij} = proportion of attacks by j^{th} instar larvae against i^{th} fruit age class ($0 \leq P \leq 1$)

A_i = proportion of total fruit in fruit population belonging to i^{th} age class ($0 \leq A \leq 1$)

S_{ij} = relative preference ($0 \leq S \leq 1$) that j^{th} instar larvae have for i^{th} fruit age class

C_{ij} = relative within-plant stratification coefficient ($0 \leq C \leq 1$) of j^{th} instar larvae for i^{th} fruit age class

The number damaged in each age class is totaled for small larvae (instars 1-3) and large larvae (instars 4-5). This number is passed to the DAMAGE subroutine and is distributed within the cotton plant.

If percent square and boll damage are entered, then the number of fruit on the plant is estimated by GOSSYM. The percent damage is converted to number damaged. This damage is distributed among the age classes of fruit by assuming that the amount of damage occurring in each age class is directly proportional to the number present. The

total number of fruit damaged within each age class is calculated and this number is passed to the subroutine DAMAGE.

FRUTDMG(I) = PROP(I) * NUM

where:

FRUTDMG(I) = number of fruit in each age class damaged by Heliothis larvae

PROP(I) = proportion of fruit in each age class

NUM = number of fruit damaged per acre by Heliothis

DAMAGE

Most of the Heliothis damaged fruit occurs in the upper part of the plant (Gonzalez et al. 1967, Fye 1972, Ramahlo et al. 1984) and close to the mainstem, with over 80 percent within three fruiting sites from the mainstem (Nicholson 1975, Ramahlo et al. 1984).

Therefore, this subroutine weights the distribution of damaged fruit vertically and horizontally on the plant.

It is assumed that the number of fruit damaged on the mainstem and vegetative stems is proportional to the number of fruit on these stems. Damaged fruit is distributed vertically on the mainstem based on the larval instar. The mainstem is divided into three equal regions and the vegetative stems are grouped in region 4 (fig. 2). The amount of damage occurring in each region on the mainstem is based on information from Ramahlo et al. (1984) (table 1). These percentages are used in the model to distribute the Heliothis damage vertically on the cotton plant.

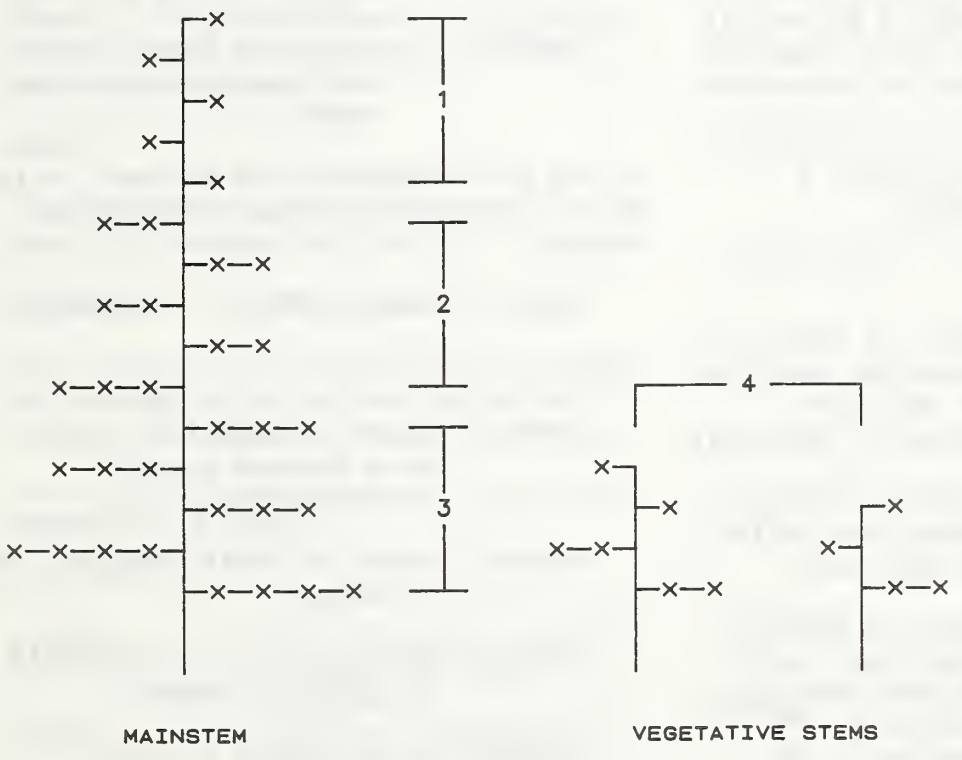

Figure 2
Diagram of simulated cotton plant showing regions used in distributing Heliothis damaged fruit. (x = fruiting site)

Table 1
Percent of fruit damage caused by Heliothis larvae occurring vertically per region on cotton plant's mainstem

Region of mainstem	Small larvae[1/]	Large larvae[2/]	Scouting report
Upper 1/3	50	39	45
Middle 1/3	37	43	40
Lower 1/3	13	18	15

[1/] Instars 1-3.
[2/] Instars 4-5.

Once the number of fruit to be damaged within each region on the mainstem is calculated, the damage is distributed on each fruiting branch based on the distance of the fruiting site from the mainstem. Ramahlo et al. (1984) found that approximately 54 percent of the damage occurred at the first site on the fruiting branch, 23 percent at the second, 12 percent at the third, 5.5 percent at the fourth, and 5.5 percent at the fifth. The amount of fruit damage at each position on the branch is calculated by--

POSDMG(IR,M,IC) = CREG(IR,IC) * BPER(M)

where:

POSDMG(IR,M,IC) = number of fruit per region per position per age class damaged by Heliothis

CREG(IR,IC) = number of fruit damaged per region per age class

BPER(M) = amount of damage occurring at each fruiting site (54% position 1, 23% position 2, 12% position 3, and 5.5% positions 4 and 5)

After the number of damaged fruit is distributed on the mainstem, the fruiting sites on the vegetative stems are evaluated. Since a small proportion of the total number of fruit is on the vegetative stems, no attempt is made to weight the distribution of the damaged fruit. The number of fruit to be damaged in each age class is compared with the number present. If there is more fruit to be damaged than available, then all fruit is damaged and the remainder is stored. If enough fruit is available, then the percent of each fruit to be removed is calculated.

VDMG(IC) = CREG(4,IC)/VEG(IC)

where:

VDMG(IC) = percent of fruit to be damaged in each age class on vegetative stems because of Heliothis larvae

CREG(4,IC) = number of fruit to be damaged on vegetative stems for each age class

VEG(IC) = number of fruit in each age class on vegetative stems

If any fruit remains to be damaged, it is equally distributed among all fruiting sites.

ADDMG = REMAIN/(SFRUIT - ACTDMG)

where:

ADDMG = amount of additional fruit to be damaged on each fruiting site

REMAIN = number of fruit remaining to be damaged

SFRUIT = number of fruit susceptible to Heliothis damage

ACTDMG = actual number of fruit damaged

The percent removed from each fruiting site on the mainstem is calculated by--

HZDMG = (POSDMG(IR,M,IC)/TCLS (IR,M,IC)) + ADDMG

where:

HZDMG = percent of fruit to be removed from fruiting site due to Heliothis feeding

POSDMG(IR,M,IC) = number of fruit per region per position per age class to be damaged by Heliothis

TCLS(IR,M,IC) = number of fruit per region per position per age class susceptible to damage

ADDMG = amount of additional fruit to be damaged on each fruiting site

HZDMG is used to decrement the amount of square and boll weight and fraction of each fruiting site.

REDIST

This subroutine redistributes any remaining damaged fruit within a region.

FRMTRX

This subroutine is called at the end of the simulation and prints the percent damage occurring at each fruiting site.

DEFINITION OF TERMS

ACTDMG = actual number of fruit damaged per plant

ADDMG = amount of additional fruit to be damaged on each fruiting site

AGE(3,30,5) = age of each node (days after node initiation)

AGEBOL(3,30,5) = age of boll (days after blooming)

BEGIN(4) = first node of region

BOLABZ = number of boll abscissions

BOLWGT(3,30,5) = boll weight (grams)

BPER(5) = amount of damage occurring at each fruiting site

BUGAGE = physiological age of larva

BUGDMG(7) = number of fruit in each age class on mainstem damaged by Heliothis

BUGGY = a logical constant used to signal if Heliothis damage has occurred today

BURRN = burr nitrogen

CDMG = counts number of damaged fruit

CHZDMG(3,30,5) = cumulative loss of fruit at node due to Heliothis damage

CLASS(3,30,5) = age class of each fruit (1 = small square, 2 = medium square, 3 = large square, 4 = flower, 5 = small green boll, 6 = medium green boll, 7 = large green boll)

COTXX = weight in grams of open bolls

CREG(4,7) = number of fruit damaged per region per age class

DENOM = denominator used in calculating probability of larval attack

DMG(7) = number of fruit damaged per age class

DTOTAL(7) = number of fruit in each age class on mainstem

END(4) = last node of region

FCODE(3,30,5) = fruit code (1 = square, 2 = green boll, 3 = open boll, 4 = abscised, 5 = square marked for abscission, 6 = boll marked for abscission)

FFRUT(3,30,5) = fraction of fruit remaining at node

FRUTDMG(7) = number of fruit in each age class damaged by Heliothis larvae

FRUTLOS = fraction of fruit lost

GBOLWT = total green boll weight

GBP = percent of green boll damage

HZBUG = number of fruit damaged by Heliothis

HZDMG = percent of fruit to be removed from fruiting site

IBUGDAY = day of year damage is to occur

IC = fruit age class

ICLS = fruit age class

IOPTION = menu selection relating to type of input data

IPOS(4) = maximum number of positions on fruiting branch

IR = region

LGLARV(7) = number of fruit in each age class damaged by large larvae (instars 4-5)

LOWER = lower 1/3 of mainstem

MID = middle 1/3 of mainstem

N = counter

NBRCH = number of fruiting branches

NFBR(1) = number of fruiting branches on mainstem

NNID = node number on fruiting branch

NNOD(3,30) = number of nodes on fruiting branch

NSTR = larval instar

NUM = number of larvae per acre

NVBRCH = number of vegetative branches

PDMG(5,7) = probability of damage occurring in each fruit age class by each larval instar

PLTDMG = number of fruit damaged per plant

POPPLT = plant population

POSDMG(4,5,7) = number of fruit per region per position per age class damaged by Heliothis

PQFLR = weight lost from fruit due to petal shed after blooming

PREF(5,7) = larval food preference values for various age fruit

PREFA(2,7) = larval food preference values for various age fruit for small (instars 1-3) and large (instars 4-5) larvae

PROP(7) = proportion of fruit in each age class

PVEG = proportion of fruit in each age class on vegetative stems

RDMG = number of fruit remaining to be damaged

REG(4,7) = number of fruit per age class per region

REGDMG(4,7) = number of fruit damaged per region per age class

REMAIN = number of fruit remaining to be damaged

REMN = number of fruit left over to be damaged that will be added to next position on fruiting branch

RPOS = number of fruiting sites on fruiting branch

SEEDN = seed nitrogen

SFRUIT = number of fruit susceptible to Heliothis damage

SMLARV(7) = number of fruit in each age class damaged by small larvae (instars 1-3)

SQP = percent of square damage

SQRWT(3,30,5) = weight of squares

SQRZ = total squares

STRAT(5,7) = age specific larval stratification coefficients

STRATA(2,7) = age specific larval stratification coefficients for small and large larvae

TCLASS(7) = number of fruit for each age class

TCLS(4,5,7) = number of fruit per region per position per age class susceptible to damage

TOTGB = number of green bolls

TOTSQR = number of squares

UPPER = upper 1/3 of mainstem

VDMG(7) = percent of fruit in each age class on vegetative stems damaged by Heliothis larvae

VEG(7) = number of fruit in each age class on vegetative stems

VEGP = proportion of fruit in each age class on mainstem

WTLOS = weight loss

XDIFF = number of fruit remaining to be damaged

EXAMPLE OF INPUT

Scouting report data

Day of year	% square damage	% boll damage
169	4.0	0
176	3.0	0
181	1.0	0
188	1.0	0
196	4.0	0
201	4.2	4.2
209	11.0	5.3
216	17.0	11.0
222	7.0	6.0
228	2.0	6.0

EXAMPLE OF OUTPUT[1/]

Percent fruit damaged at each location

Mainstem (K1)

	M1	M2	M3	M4	M5
L 1	8	2	3	1	0
L 2	8	3	1	0	0
L 3	23	9	3	0	0
L 4	22	10	7	0	0
L 5	26	6	0	0	0
L 6	25	13	0	0	0
L 7	27	14	0	0	0
L 8	17	0	0	0	0
L 9	17	0	0	0	0
L 10	17	0	0	0	0
L 11	0	0	0	0	0
L 12	0	0	0	0	0
L 13	0	0	0	0	0
L 14	0	0	0	0	0
L 15	0	0	0	0	0

Vegetative branch 1 (K2)

M1	M2	M3	M4	M5
20	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Vegetative branch 2 (K3)

M1	M2	M3	M4	M5
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

[1/] From HELDMG using scouting report data as input. (K = vegetative branch number, L = fruiting branch number, M = fruiting branch node number)

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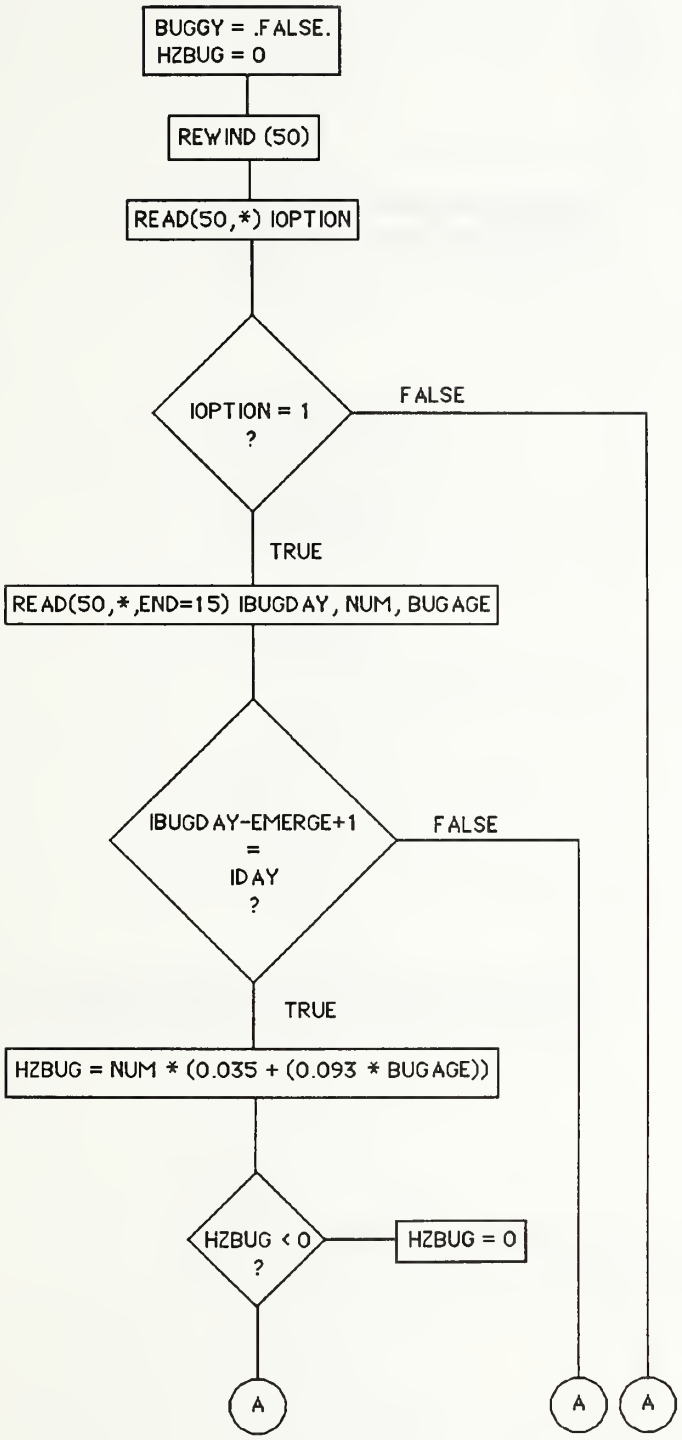
FLOW CHARTS

RDDMG



Rewind INPUT.DMG.

Read input option.

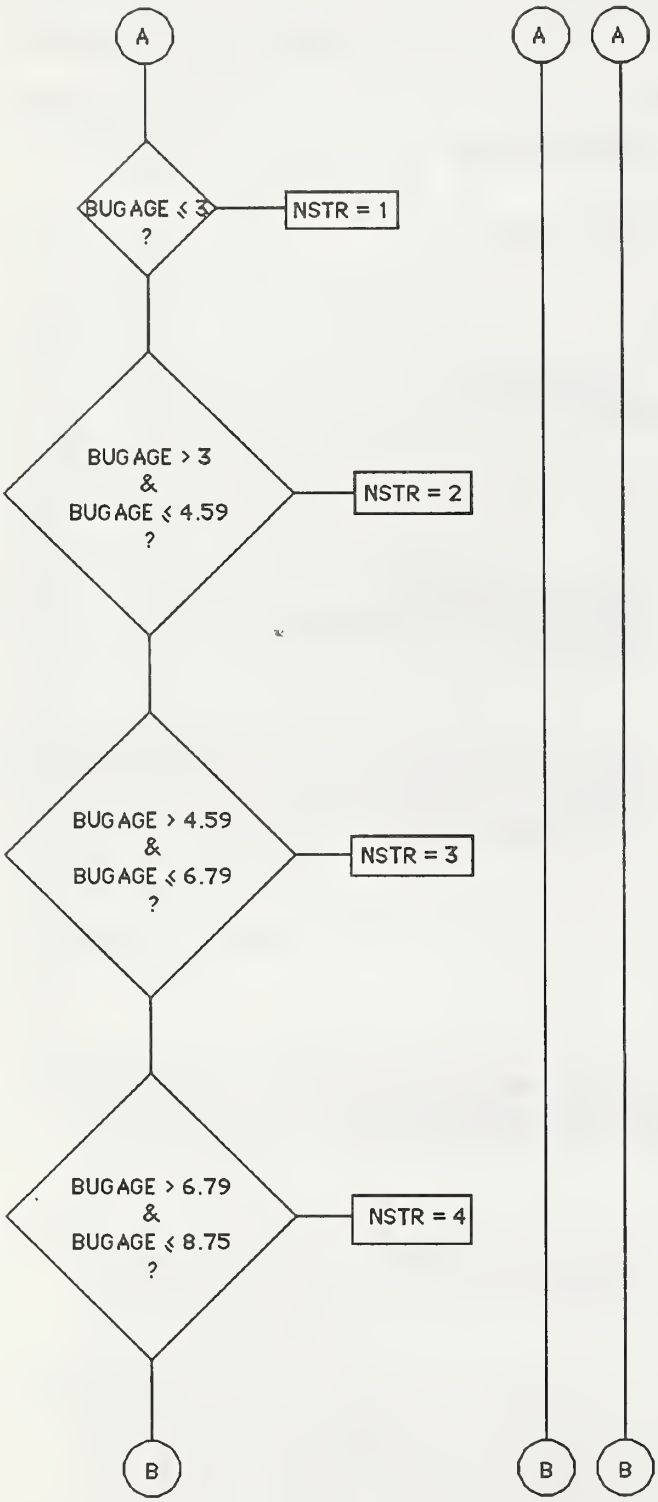
Are input data from Heliothis model?

Input day of year, number of larvae per acre, and physiological age of larvae.

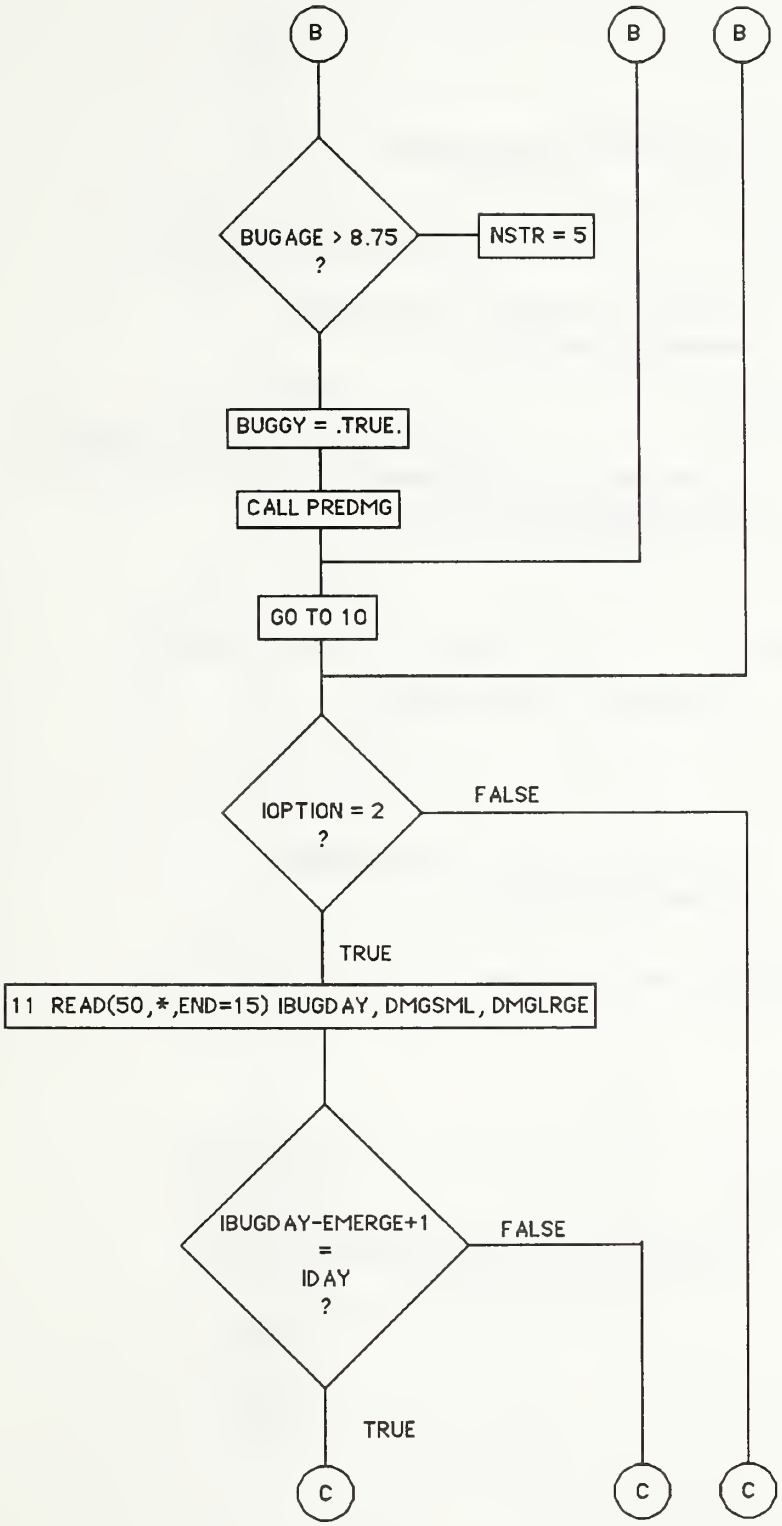
Will damage occur today?

Calculate number of fruit damaged per acre. This equation was derived by Townsend (1973).

If number of fruit damaged is less than 0, set it to 0.



Assign instars (NSTR) to larvae based on physiological age.



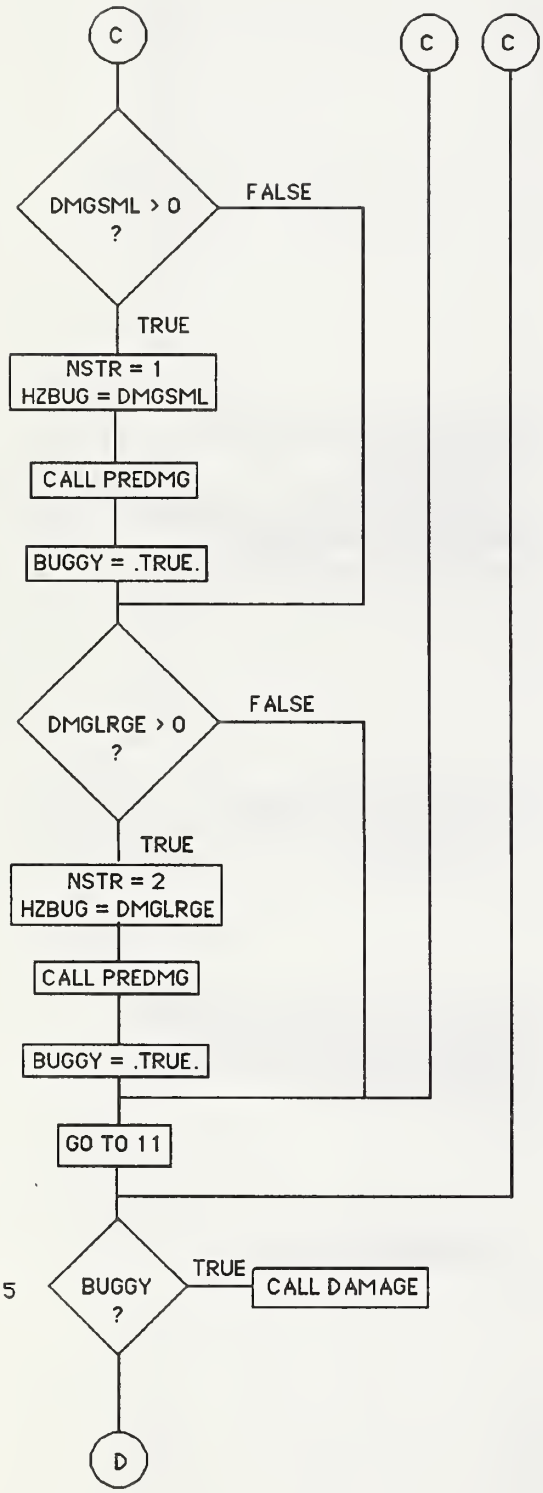
If damage will occur today, set BUGGY = TRUE.

Call PREDMG subroutine to distribute total number of damaged fruit among different age classes of fruit.

Are input data from MOTHZV?

Input day of year, number of damaged fruit per acre caused by equivalent number of small (DMGSML) and large (DMGLRGE) larvae.

Will damage occur today?



Have small larvae caused damage?

Set NSTR = 1 and HZBUG = number of fruit damaged by small larvae.

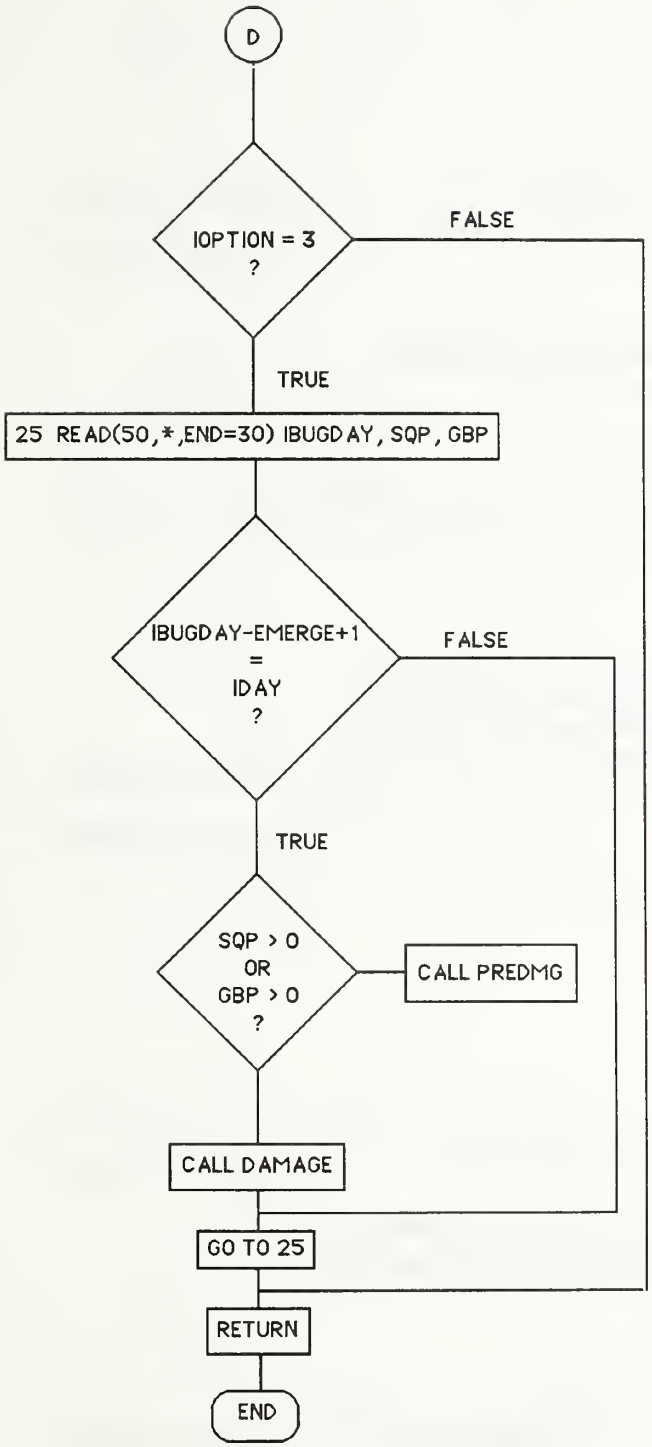
Call PREDMG subroutine to distribute damage among different age classes of fruit. Set BUGGY = true.

Have large larvae caused damage?

Set NSTR = 2 and HZBUG = number of fruit damaged by large larvae.

Call PREDMG subroutine.

If BUGGY = true, call DAMAGE subroutine.



Are input data from scouting report?

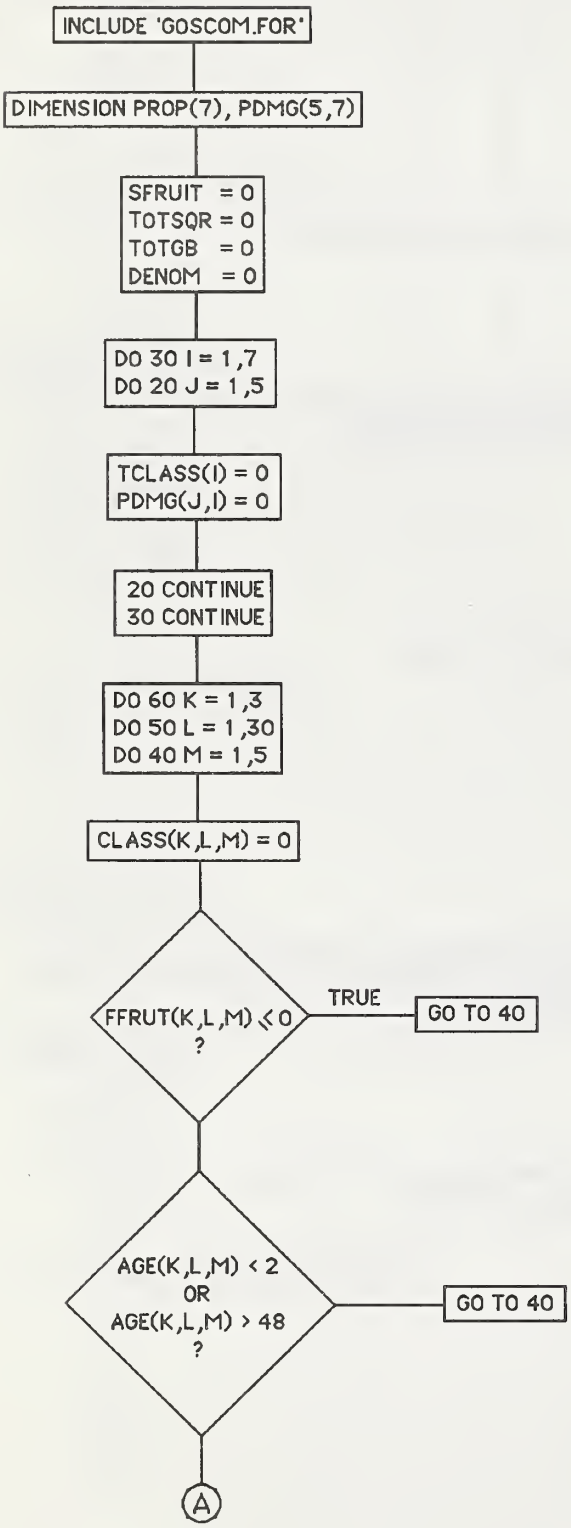
Input day of year, percent square damage, and percent green boll damage.

Will damage occur today?

If percent square damage or percent green boll damage is greater than 0, call PREDMG subroutine.

Call DAMAGE subroutine to distribute damaged fruit on plant.

PREDMG



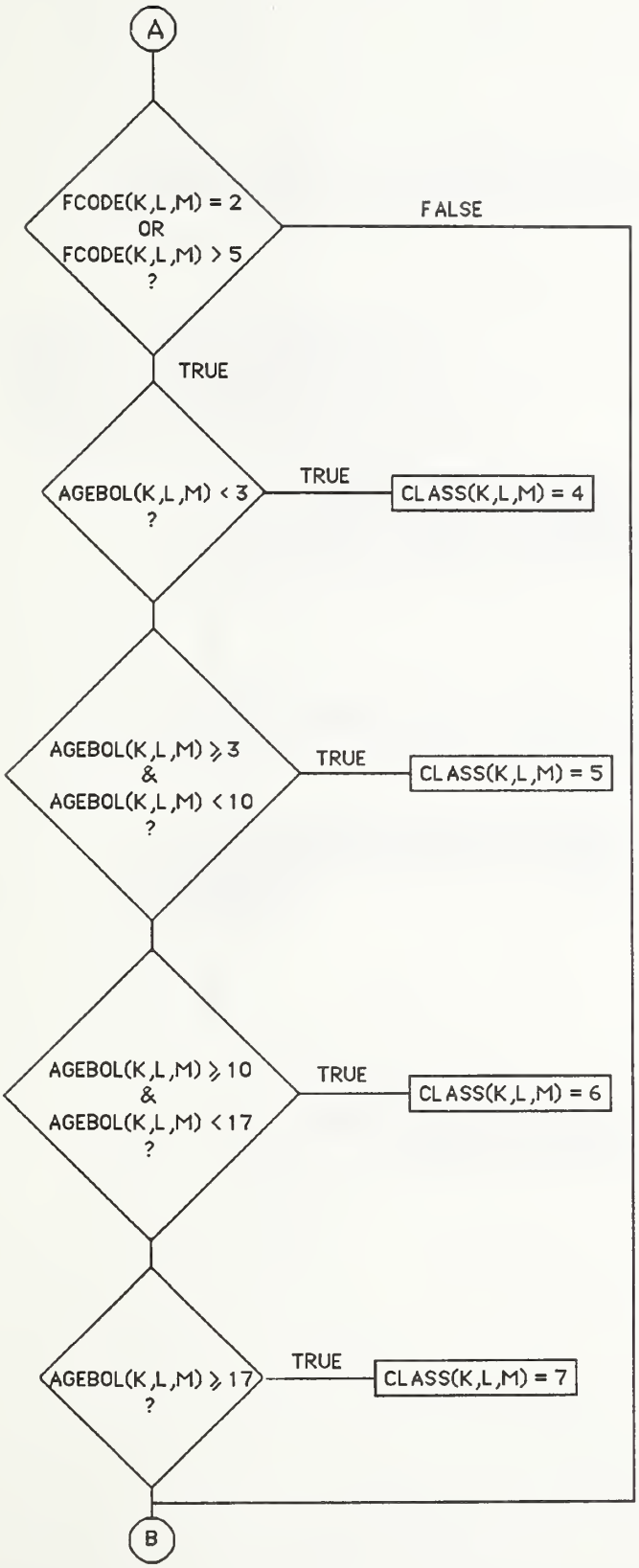
Set all counters to 0.

Do for each fruit age class (I) and each larval instar (5).

Set counters to 0.

Assign fruit to different age classes. Examine all monopodial branches (K), all sympodial branches (L), and all fruiting sites on each sympodium (M).

Fruit must be between 2 and 48 days old to be susceptible to Heliothis damage.



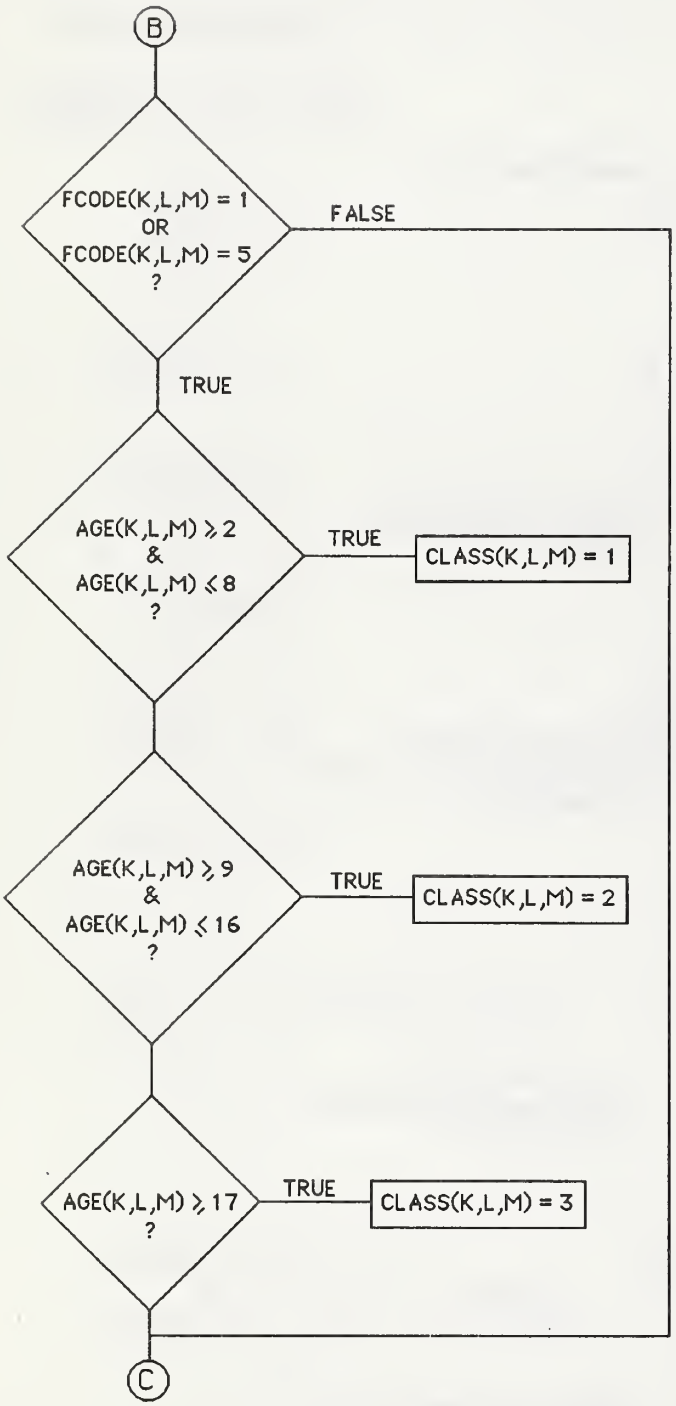
Classify green bolls.

If green boll is less than 3 days old, then consider it a bloom.

If green boll is between 2 and 10 days old, then consider it a small boll.

If green boll is between 9 and 17 days old, then consider it a medium boll.

If green boll is greater than 16 days old, then consider it a large boll.

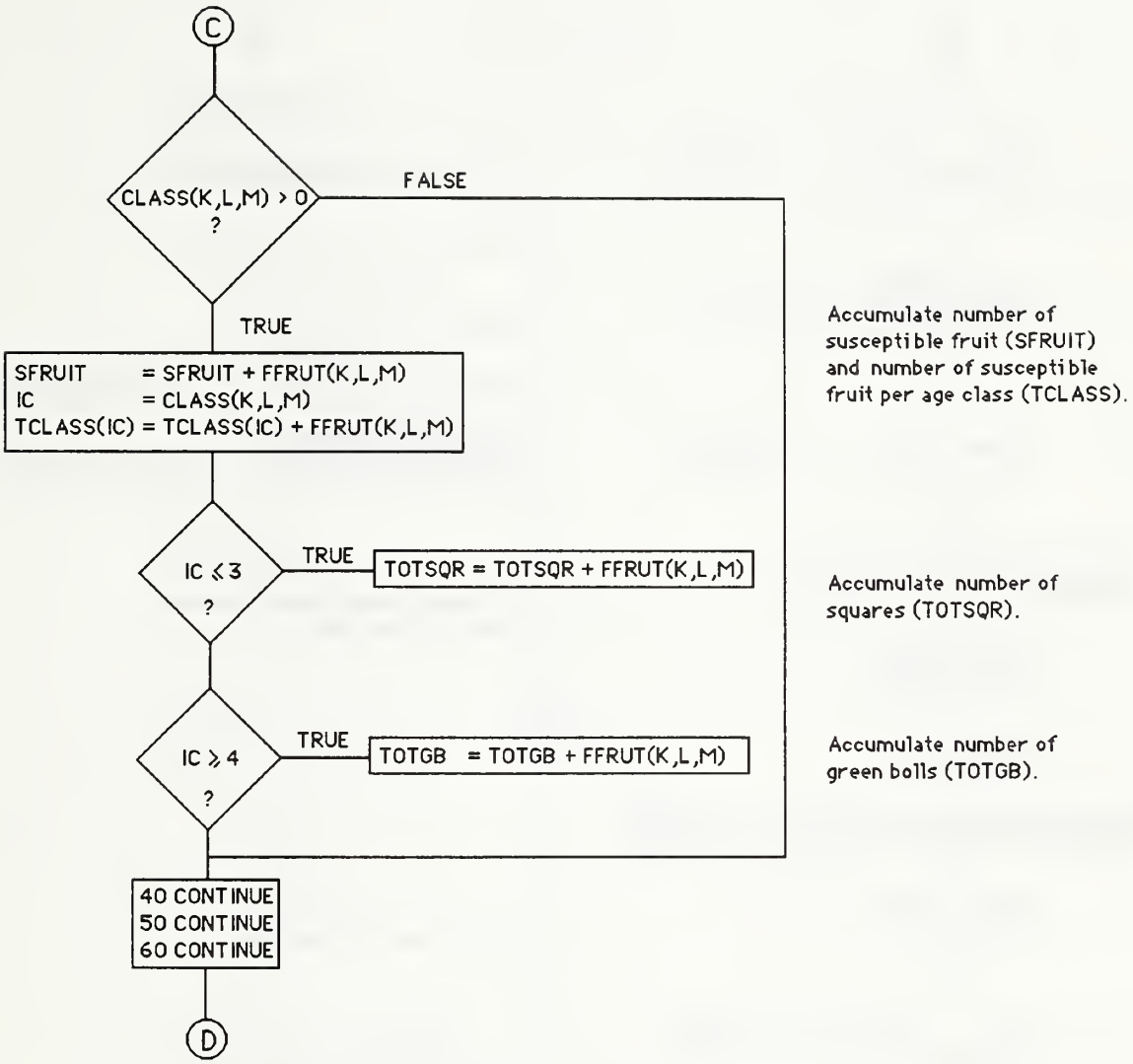


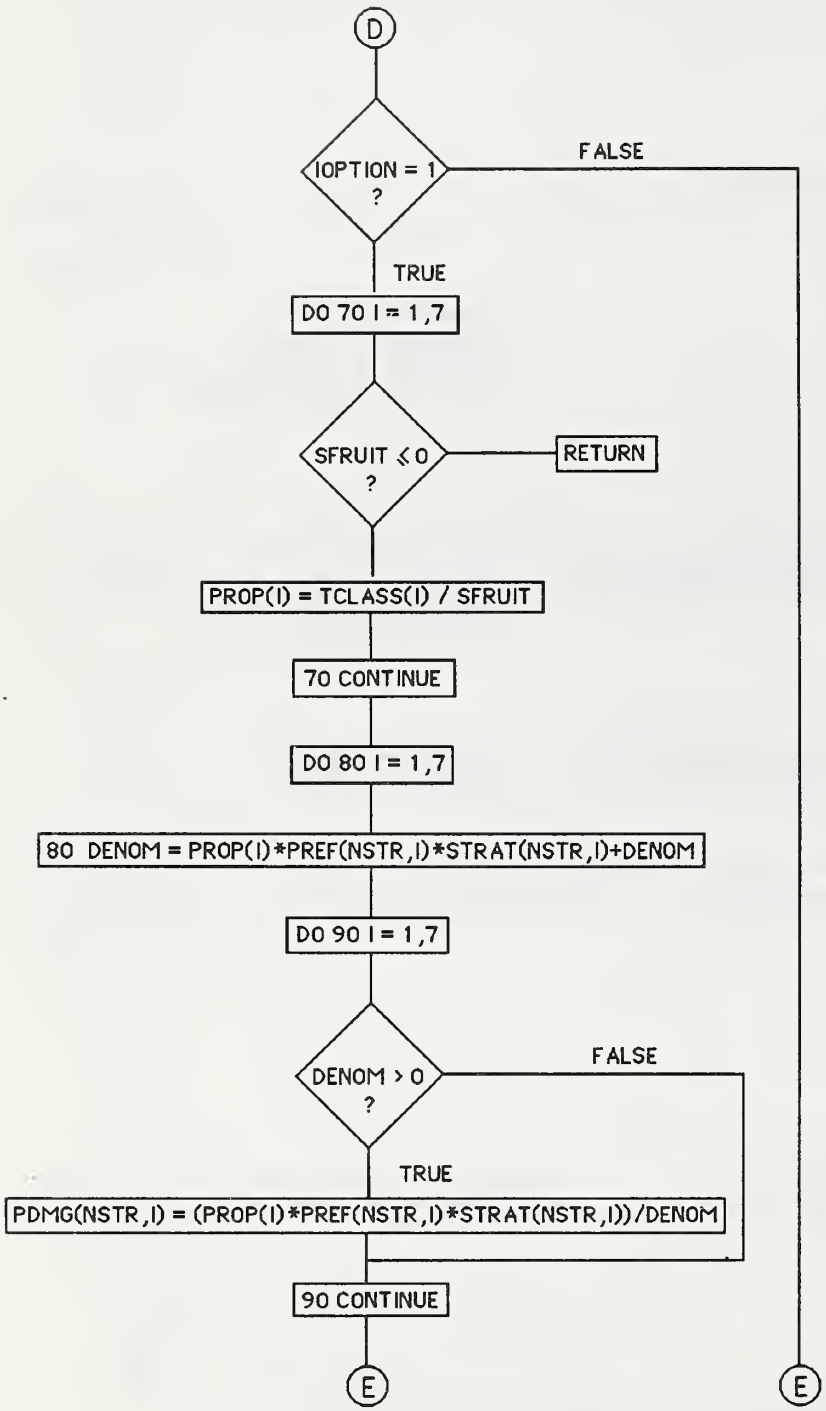
Classify squares.

If square is between 1 and 9 days old, then consider it a small square.

If square is between 8 and 17 days old, then consider it a medium square.

If square is older than 16 days, then consider it large.


C
CLASS(K,L,M) > 0
?
FALSE
TRUE
SFRUIT = SFRUIT + FFRUT(K,L,M)
IC = CLASS(K,L,M)
TCLASS(IC) = TCLASS(IC) + FFRUT(K,L,M)
Accumulate number of susceptible fruit (SFRUIT) and number of susceptible fruit per age class (TCLASS).
IC ⩽ 3
?
TRUE
TOTSQR = TOTSQR + FFRUT(K,L,M)
Accumulate number of squares (TOTSQR).
IC ⩾ 4
?
TRUE
TOTGB = TOTGB + FFRUT(K,L,M)
Accumulate number of green bolls (TOTGB).
40 CONTINUE
50 CONTINUE
60 CONTINUE
D



Input data from Heliothis model.

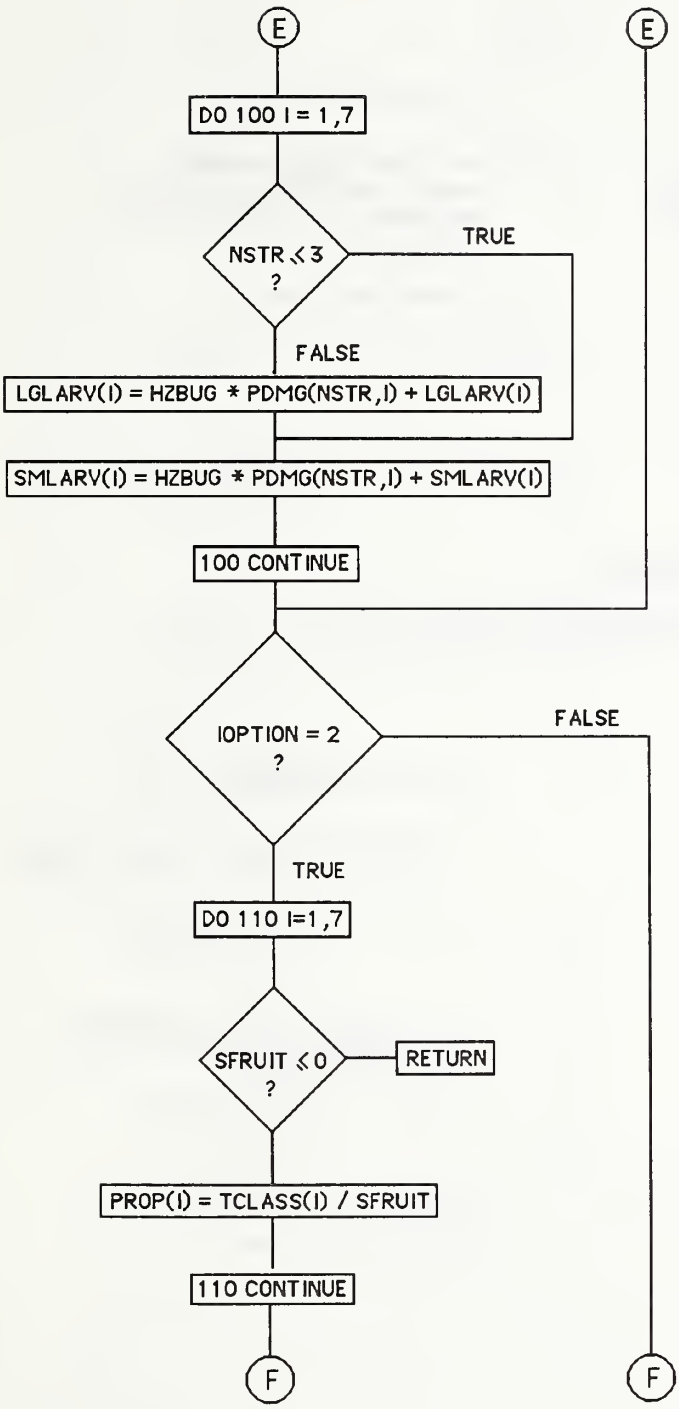
Do for each fruit age class.

If no fruit is available, return to main program.

Calculate proportion of each age class of fruit (PROP).

Do for each fruit age class.

Distribute damaged fruit among age classes based on preference (PREF) and stratification (STRAT) coefficients derived by Wilson and Gutierrez (1980).



For each fruit age class :

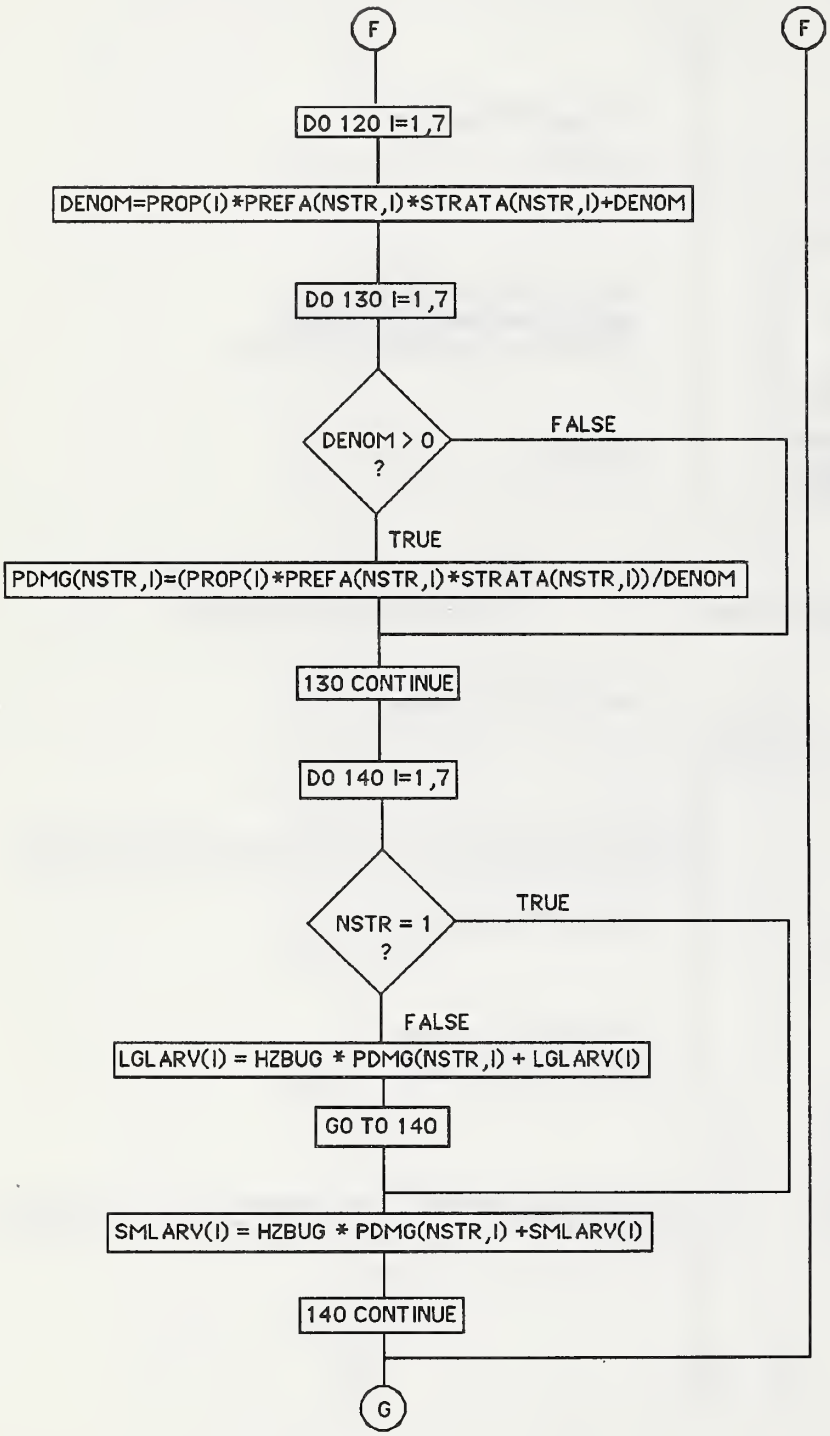
Calculate number of fruit of each age class damaged by small larvae (SMLARV) and large larvae (LGLARV).

Input data from MOTHZV.

For each fruit age class :

If no fruit is available, return to main program.

Calculate proportion of each age class of fruit.



For each fruit age class :

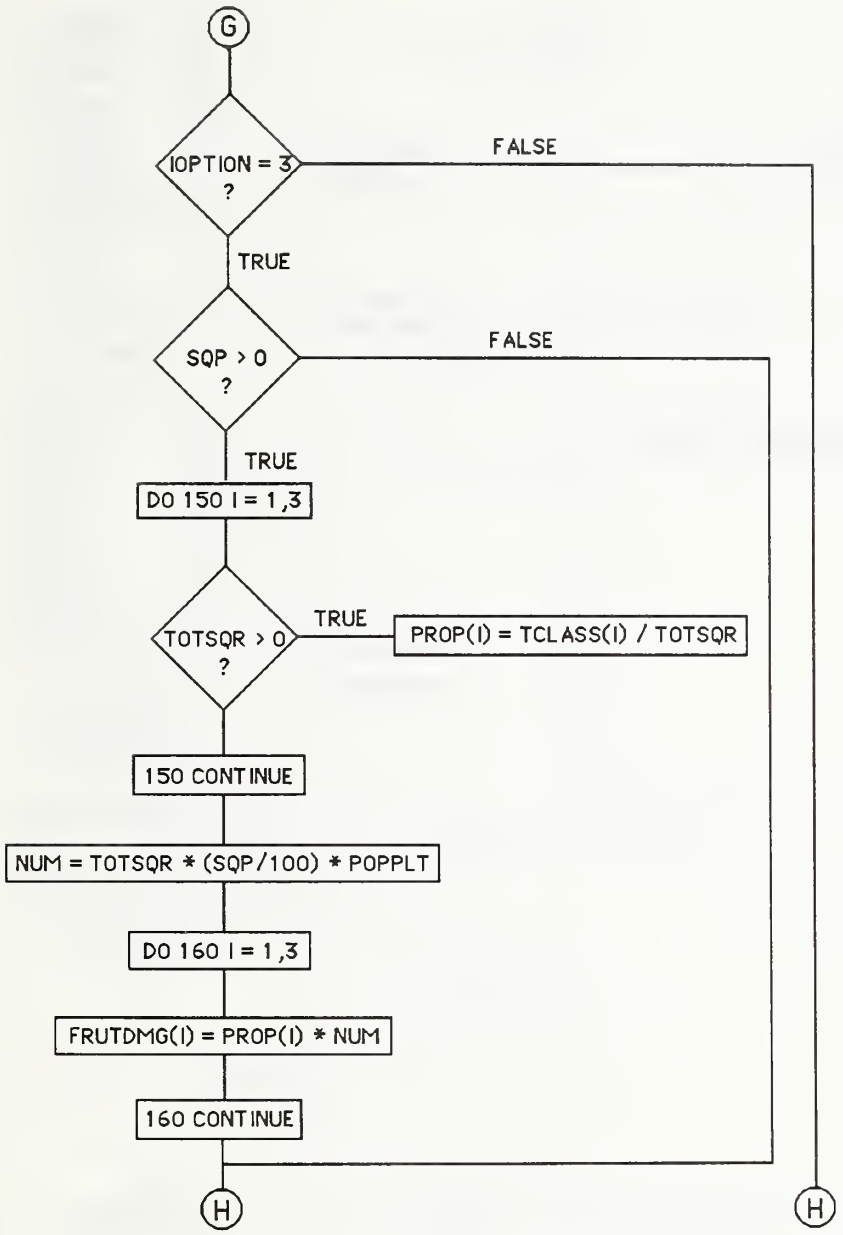
Same logic as Heliothis model, except preference and stratification coefficients averaged for instar 1-3 and instar 4-5.

For each fruit age class :

For each fruit age class :

Calculate number of fruit to be damaged by large larvae.

Calculate number of fruit to be damaged by small larvae.



Input data from scouting report.

If percent square damage is 0, skip to green boll section.

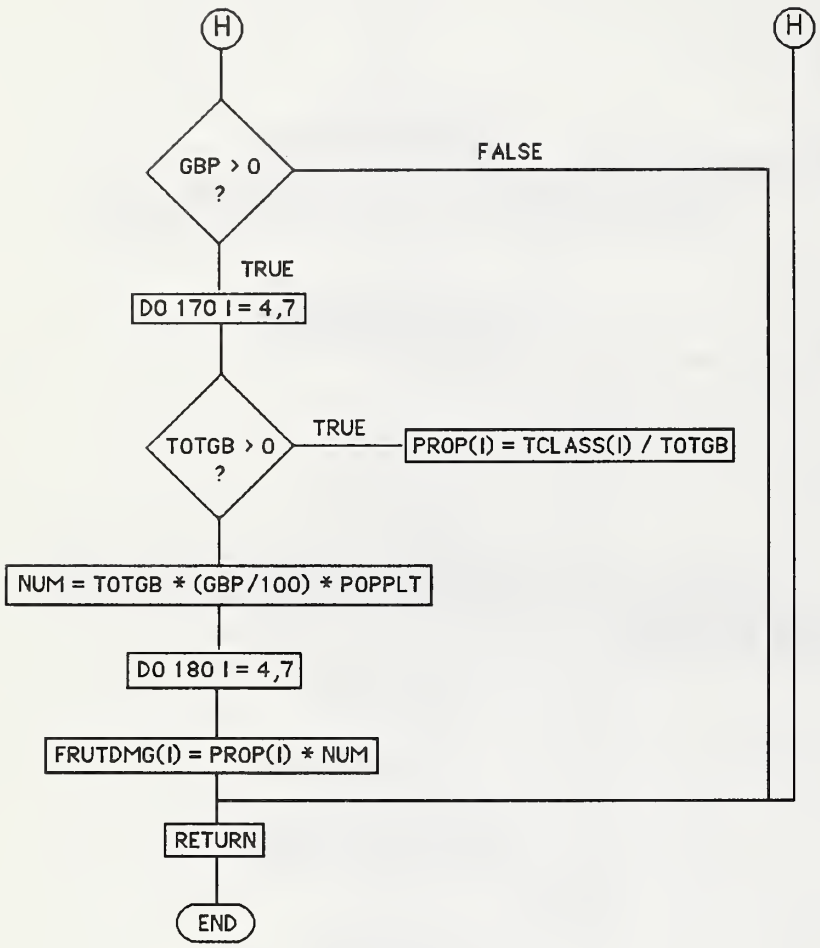
For each size square :

Calculate proportion of squares in each age class.

Calculate number of fruit damaged per acre (NUM).

For each size square :

Number of fruit damaged in each age class is proportional to number present.

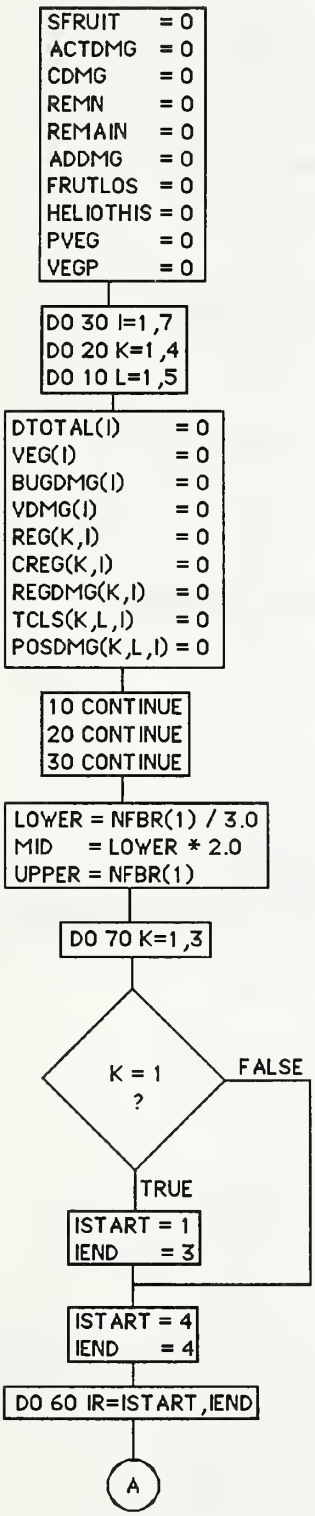


Same logic for green bolls.

For each size green boll :

For each size green boll :

DAMAGE



Set all counters to 0.

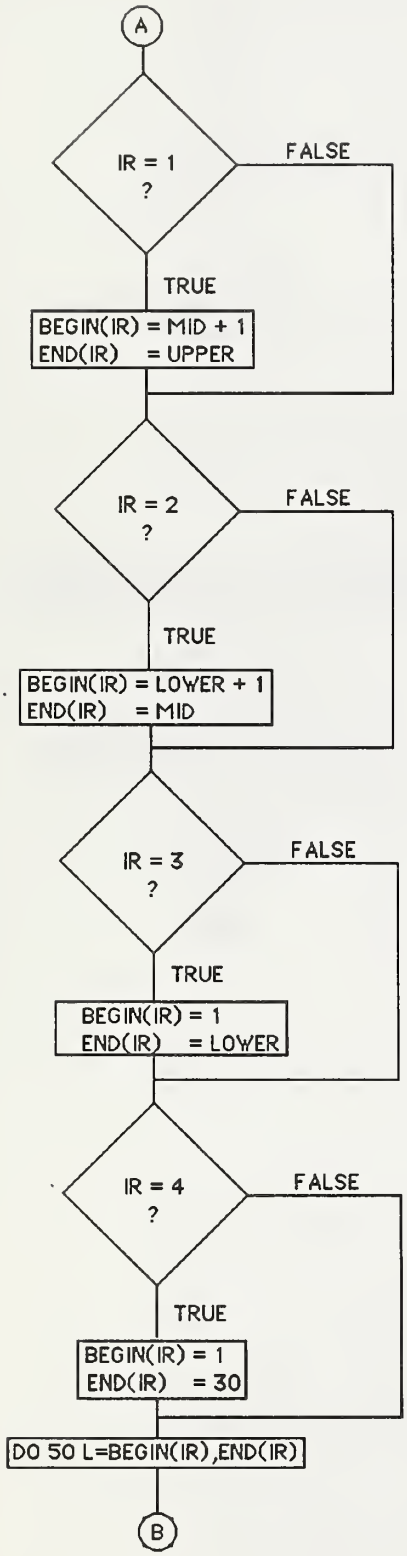
For each fruit age class (I), each region (K), and each fruiting site (L) on sympodium :

Set counters to 0.

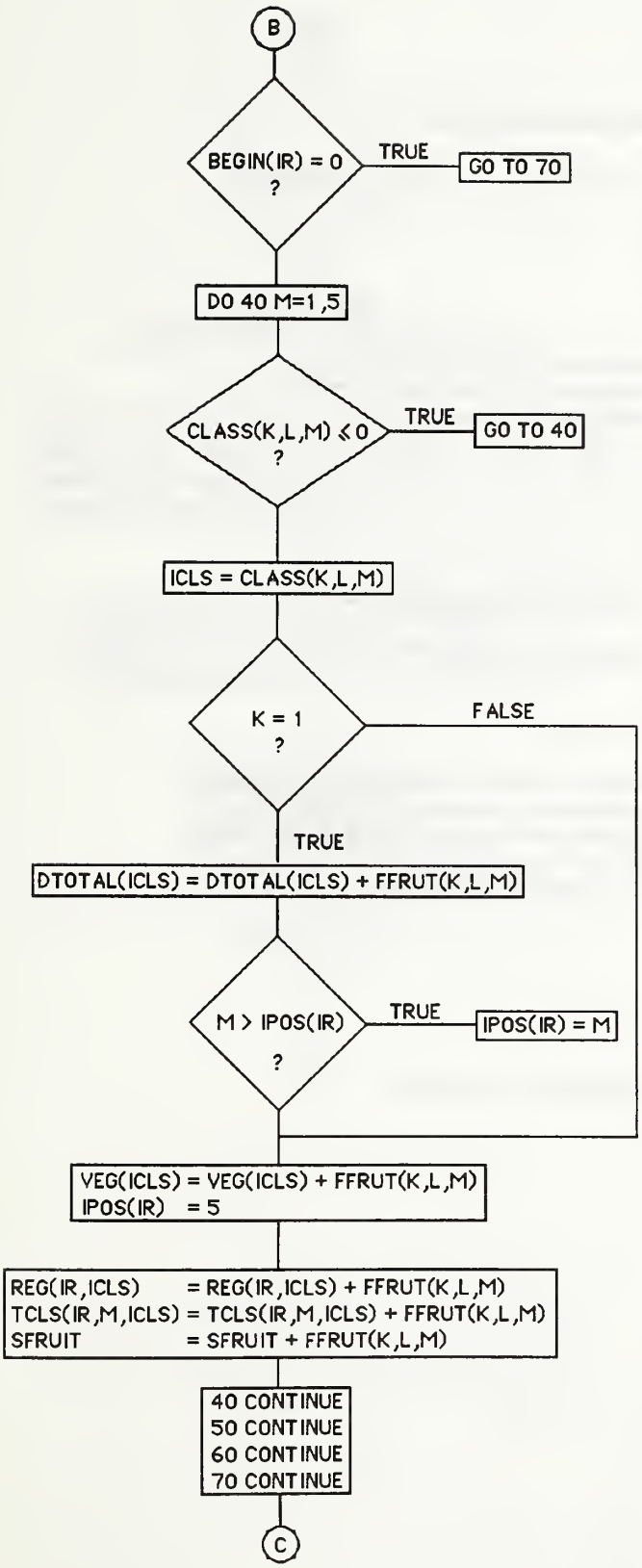
Divide plant into thirds based on number of mainstem nodes.

Consider each stem.
1 = mainstem.
2 & 3 = vegetative stems.

Regions 1-3 are for mainstem only and region 4 is for both vegetative stems.



Assign beginning and ending node for each region.



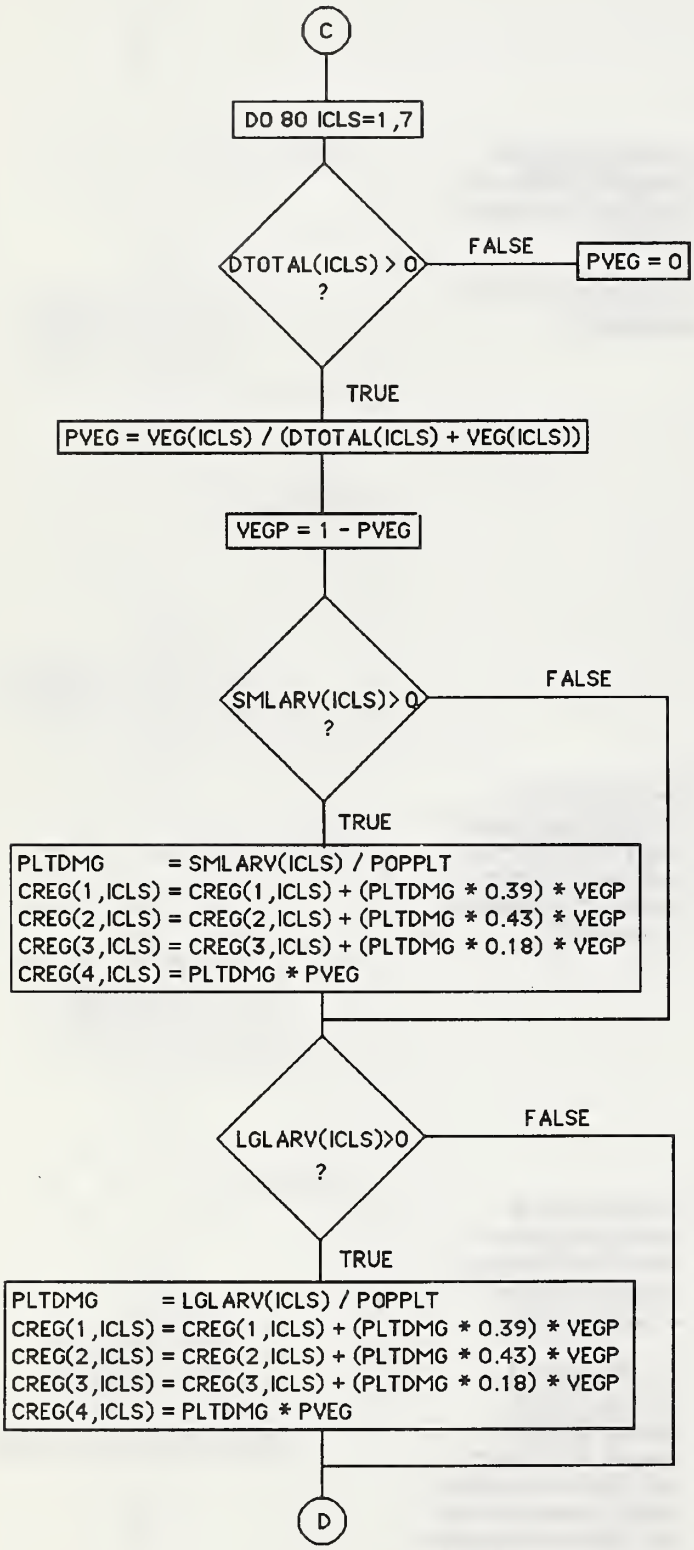
This section counts number of fruit in each age class available for damage.

For each fruiting site on sympodium :

Count number of fruit per age class on mainstem (DTOTAL) and store maximum number of positions per region (IPOS).

Count number of fruit on vegetative stems (VEG) and set maximum number of positions to 5.

Count number of fruit available to damage (SFRUIT), number of fruit per age class in each region (REG), number of fruit per age class per region in each position (TCLS).



For each fruit age class :

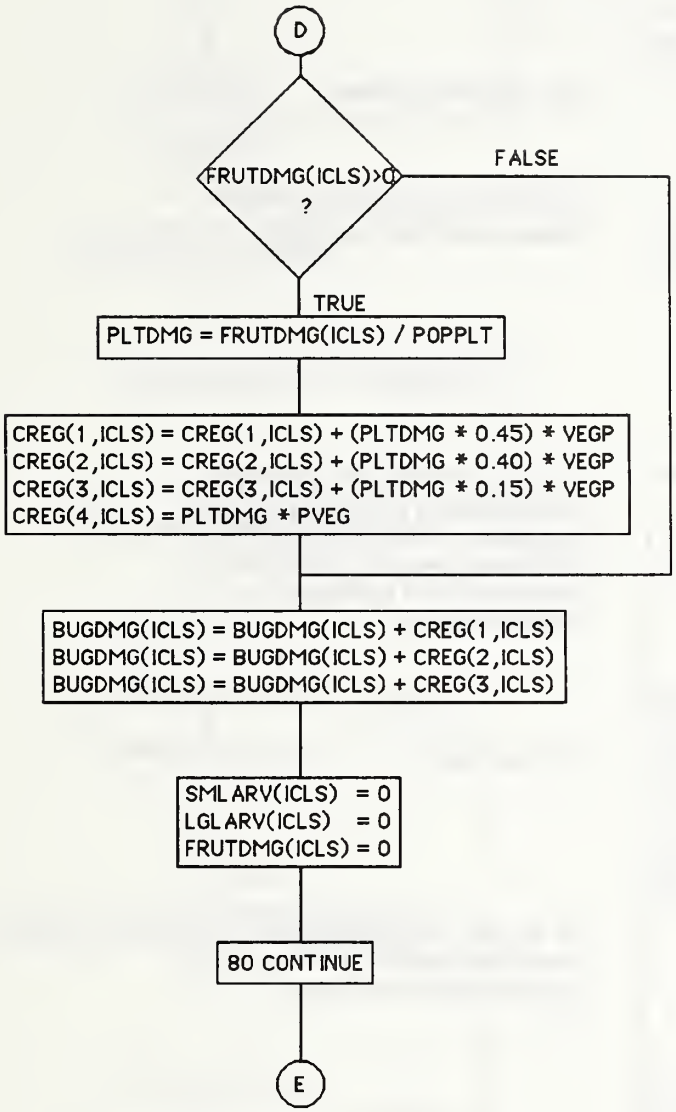
Calculate proportion of fruit on mainstem (VEGP) and vegetative stems (PVEG) for each age class.

Information from Heliothis model.

Small larvae - instars 1-3.

Number of fruit to be damaged per age class is converted to per plant basis (PLTDMG) and number to be damaged is weighted vertically for each region (CREG) based on information from Ramahlo et al. (1984).

Large larvae - instars 4-5.



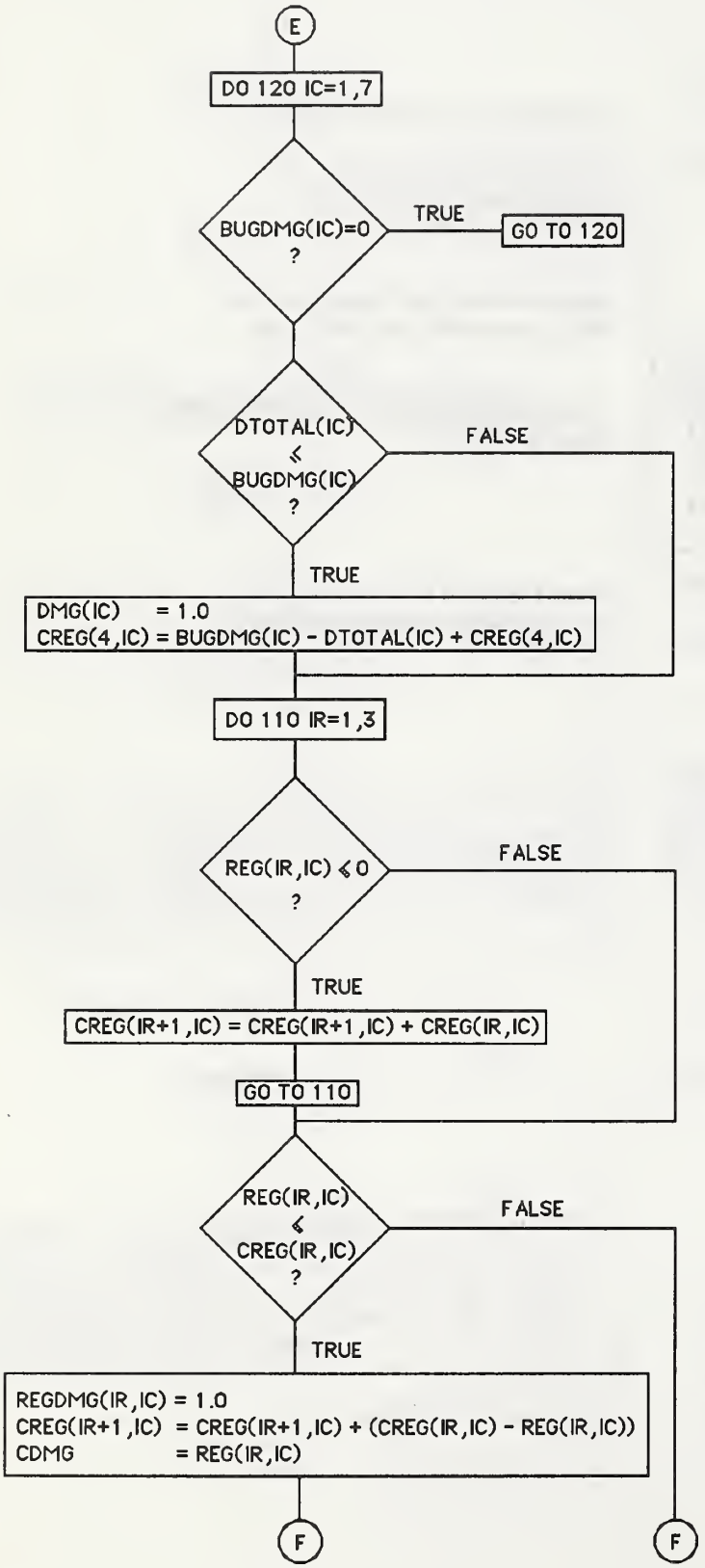
Information from scouting reports.

If no fruit of this age class is to be damaged, skip to next age class.

Number of fruit to be damaged per age class is converted to per plant basis.

Number to be damaged is weighted vertically for each region.

Count number of fruit to be damaged per age class on mainstem (BUGDMG).



For each fruit age class :

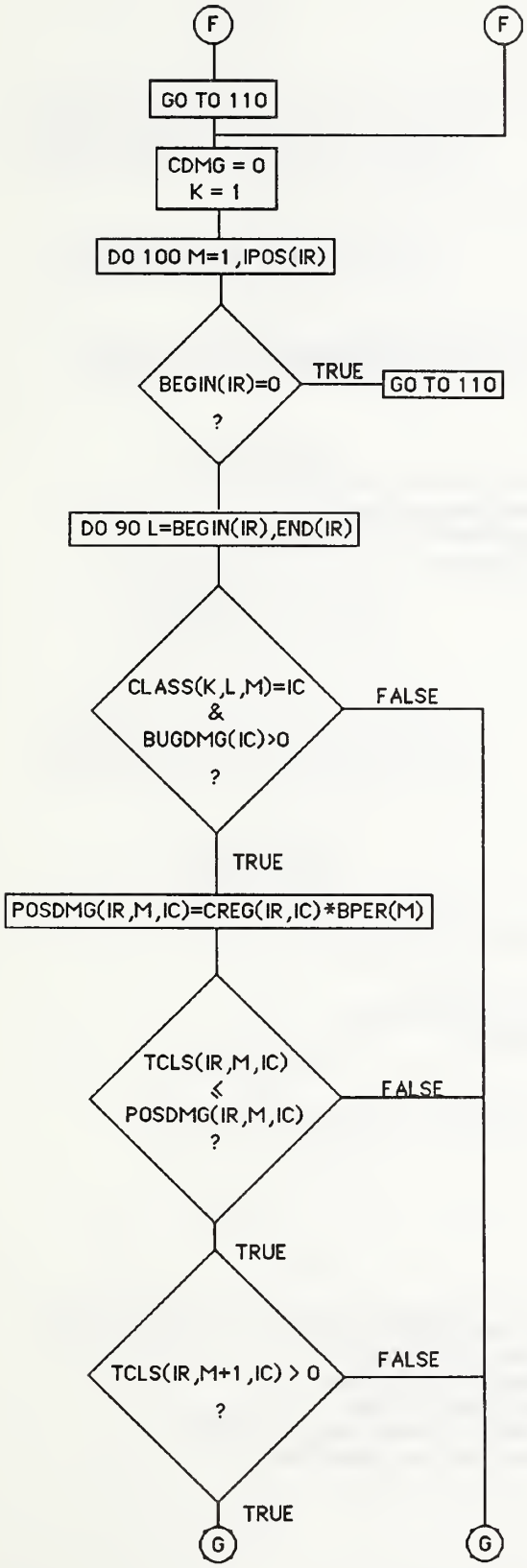
If no fruit of this age class is to be damaged, skip to next age class.

If number of fruit in this age class to be damaged is greater than or equal to number available, then set DMG for that age class to 1.0 and move any remaining fruit to be damaged to vegetative stems.

For each region :

If no fruit is in this age class within this region, then move number to be damaged to next region.

If number of fruit in this age class to be damaged is greater than or equal to number available, then set REGDMG for that age class to 1.0 and move any remaining fruit to be damaged to next region.

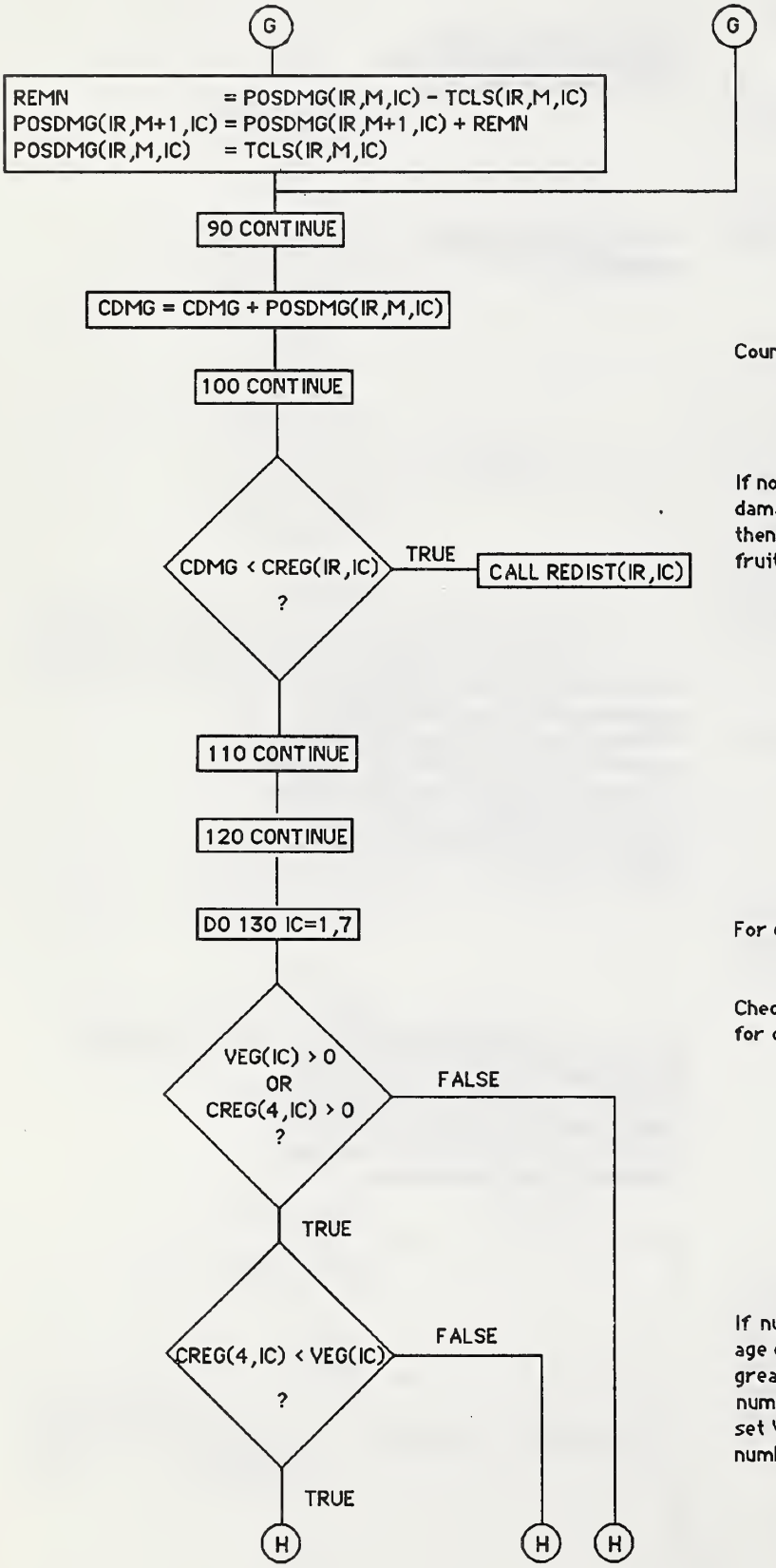


If more fruit is available than needs to be damaged, then consider each fruiting site.

For each fruiting site on sympodium :

If fruit at this site is in correct age class and this age class is to be damaged, then calculate percent to remove from this site (POSDMG). Damage is weighted horizontally based on distance from mainstem (BPER). Weighting is based on information from Ramahlo et al. (1984).

If number of fruit in this age class to be damaged is greater than or equal to number available, then set POSDMG equal to number available (TCLS) and move any remaining fruit to be damaged to next position on fruiting branch.



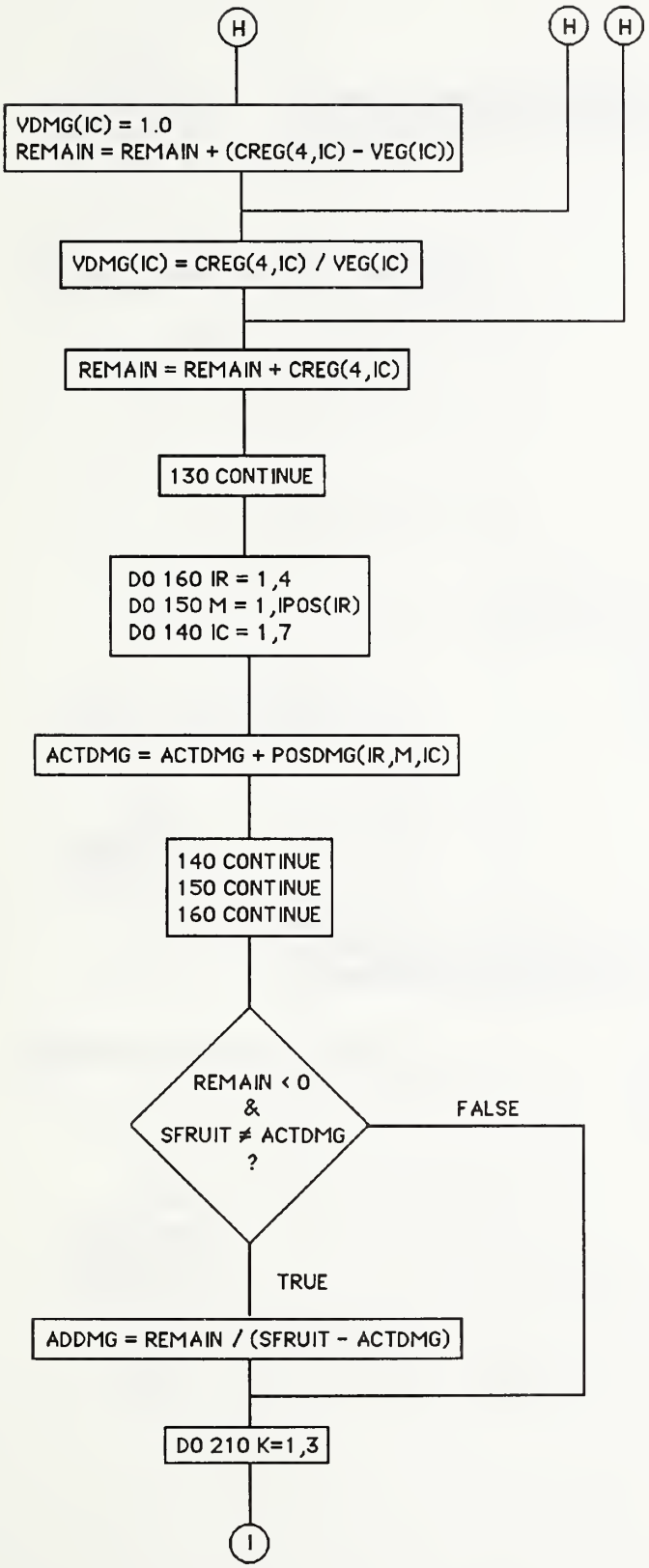
Count number of fruit damaged.

If not enough fruit has been damaged from this region, then call REDIST to redistribute fruit by position.

For each fruit age class :

Check vegetative stems for damage.

If number of fruit of age class to be damaged is greater than or equal to number available, then set VDMG = 1.0 and store number of any remaining fruit.

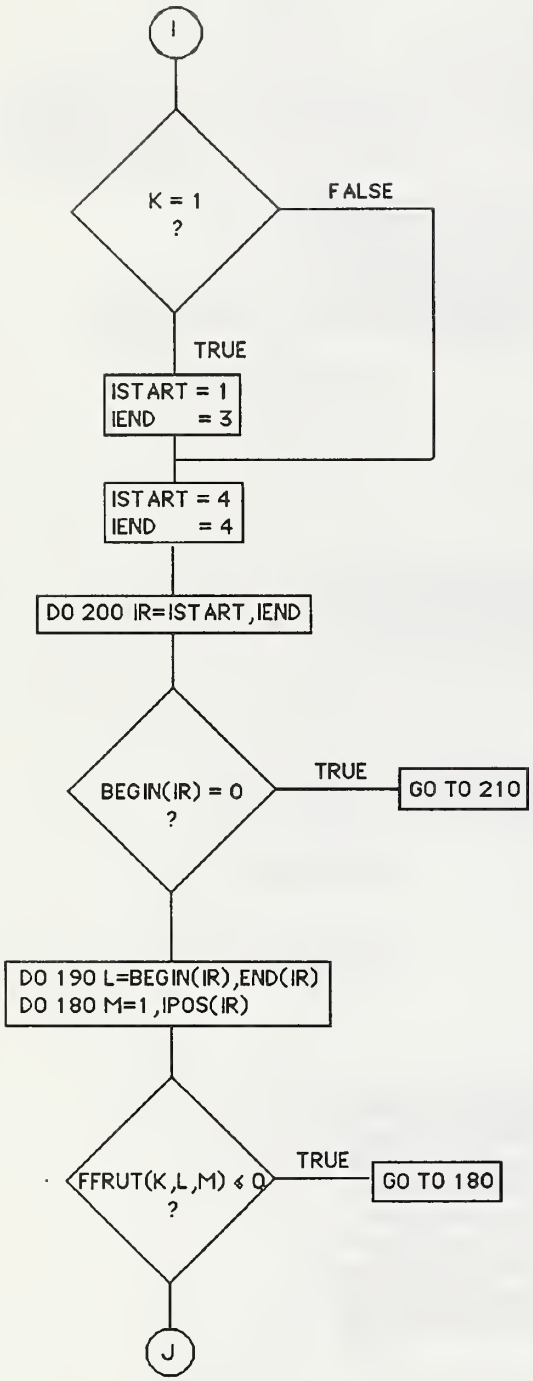


If more fruit is available for this age class than needs to be damaged, then calculate percent damaged per age class (VDMG).

For each plant region (IR), for each fruiting site on fruiting branch (M), and for each fruit age class (IC):

Count number of fruit damaged (ACTDMG).

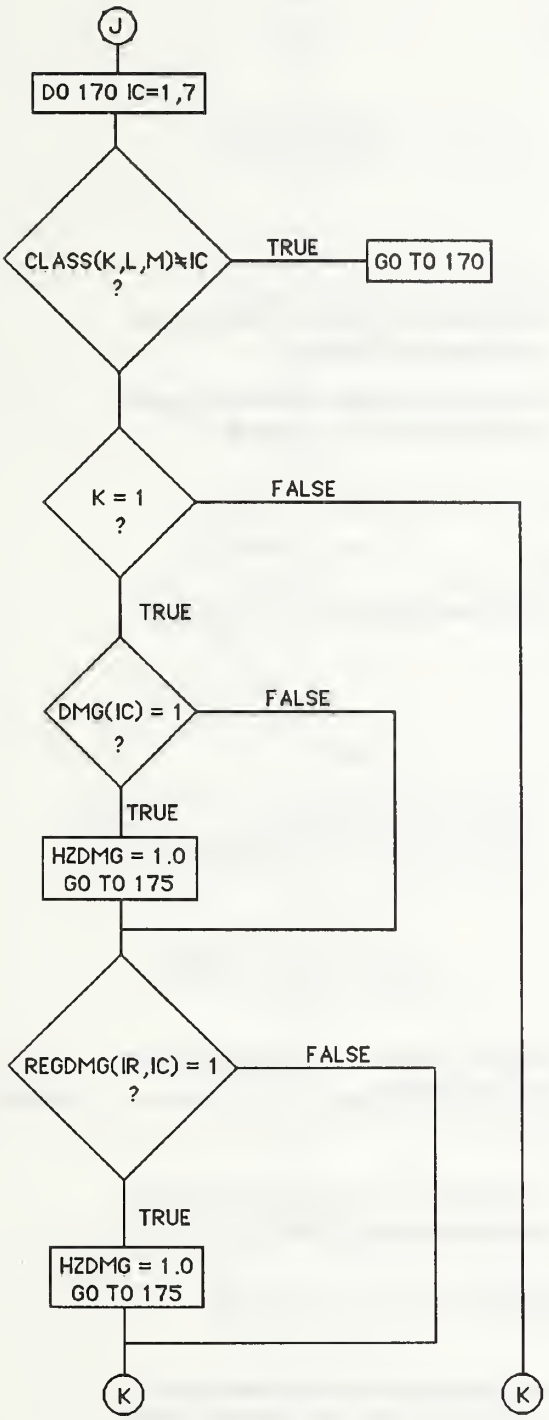
If number of fruit remaining to be damaged after considering vegetative stems is greater than 0 and number of available fruit is not equal to remaining fruit to be damaged, then distribute remaining fruit to be damaged evenly over all fruit on plant (ADDMG).



This next section calculates actual percent damage for each fruiting site.

For each region :

For each sympodium (L) in region and each fruiting site on sympodium (M) :

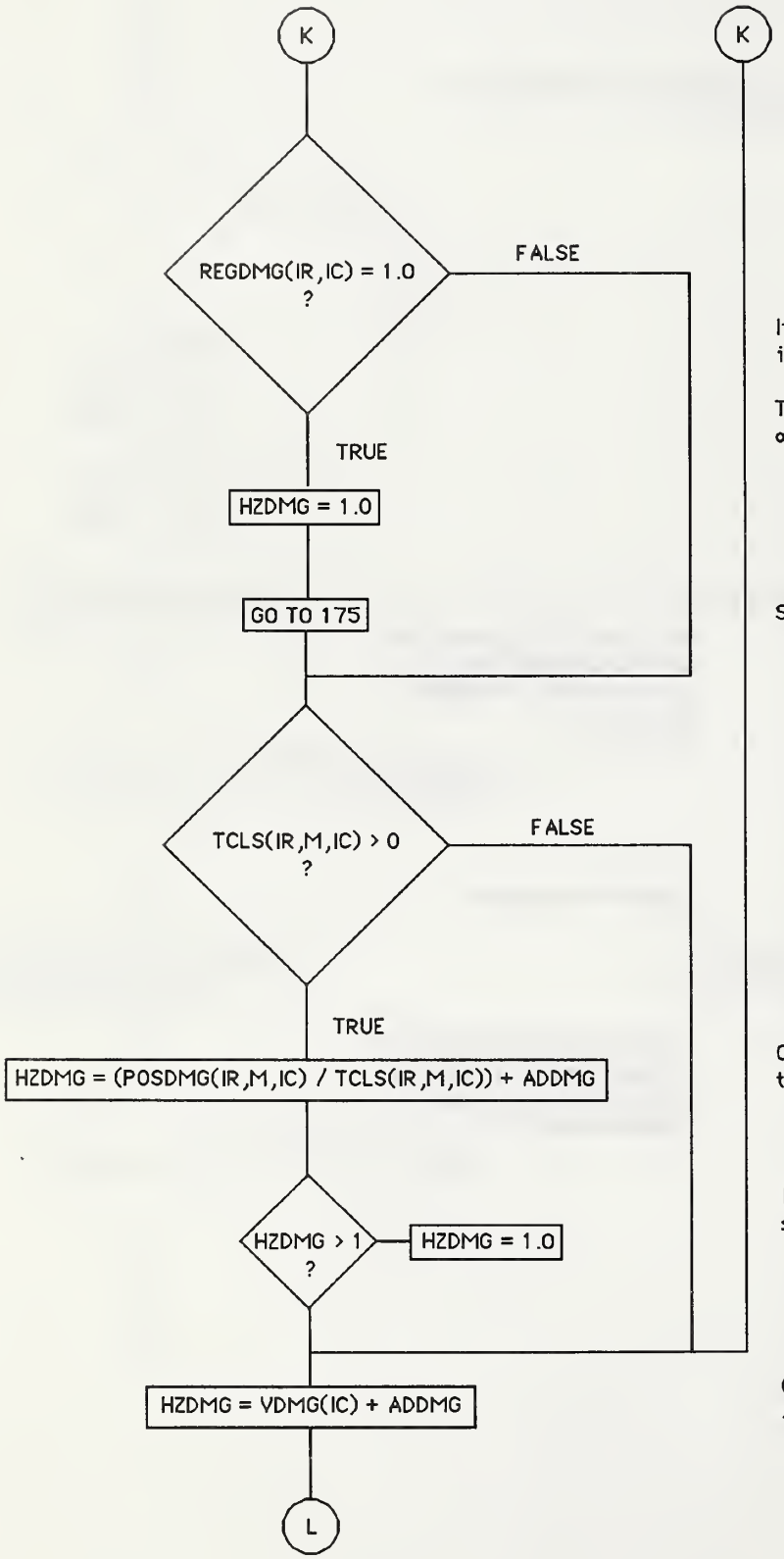


For each fruit age class :

If all fruit within this age class is to be damaged, then set percent to remove (HZDMG) equal to 1.0.

Skip to next age class.

If all fruit within this age class in this region is to be damaged, then set percent to remove (HZDMG) equal to 1.0.



If all fruit in this region of this age class is damaged, set HZDMG = 1.

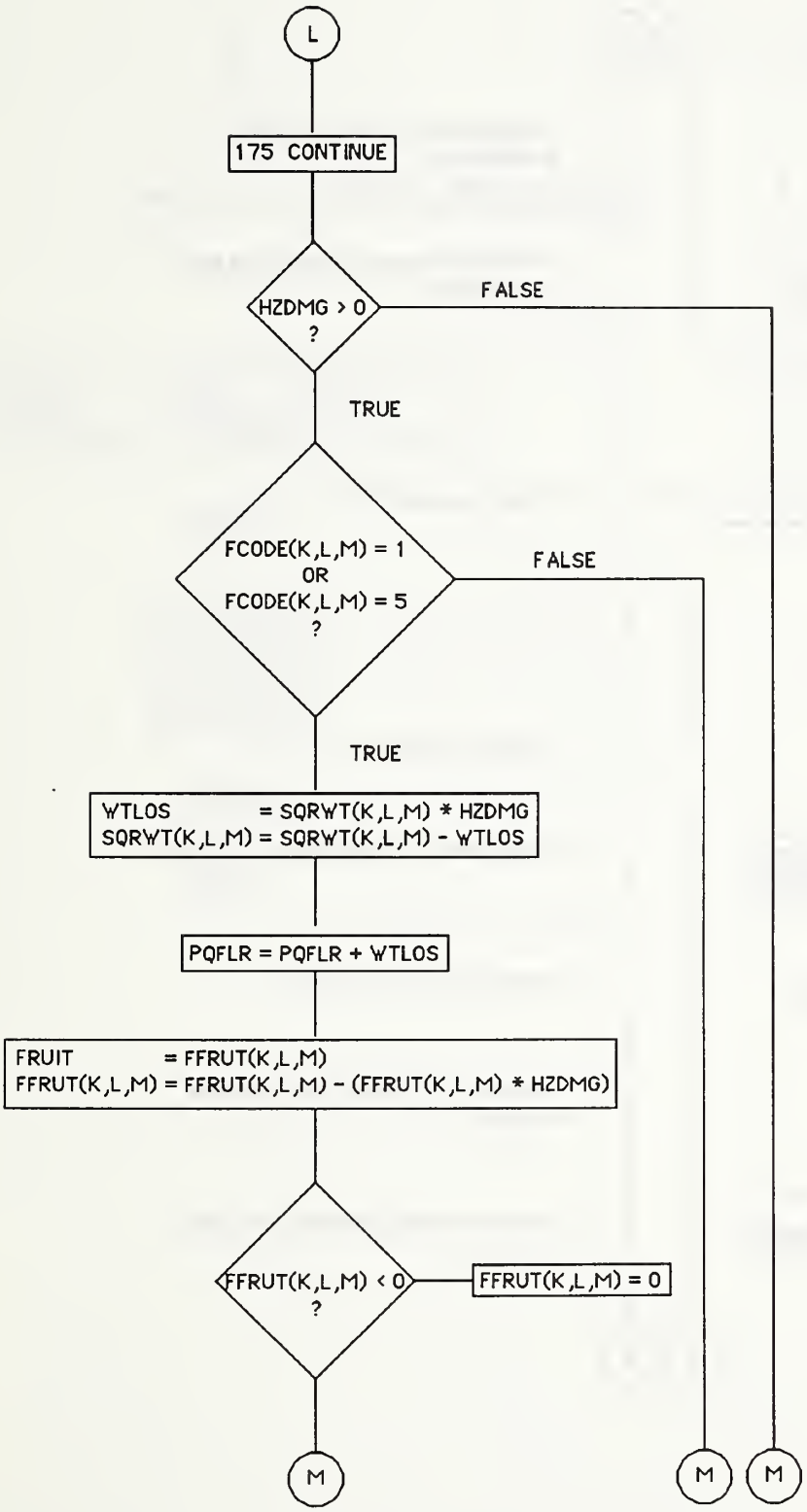
This will cause all fruit within this region of this age class to be removed.

Skip to next age class.

Calculate fraction of fruit to remove from this fruiting site.

If fraction to remove from this fruiting site becomes greater than 1, set it to 1.

Calculate fraction of fruit within this age class to remove on vegetative stems.



Actual removal of fruit from each fruiting site due to Heliothis feeding.

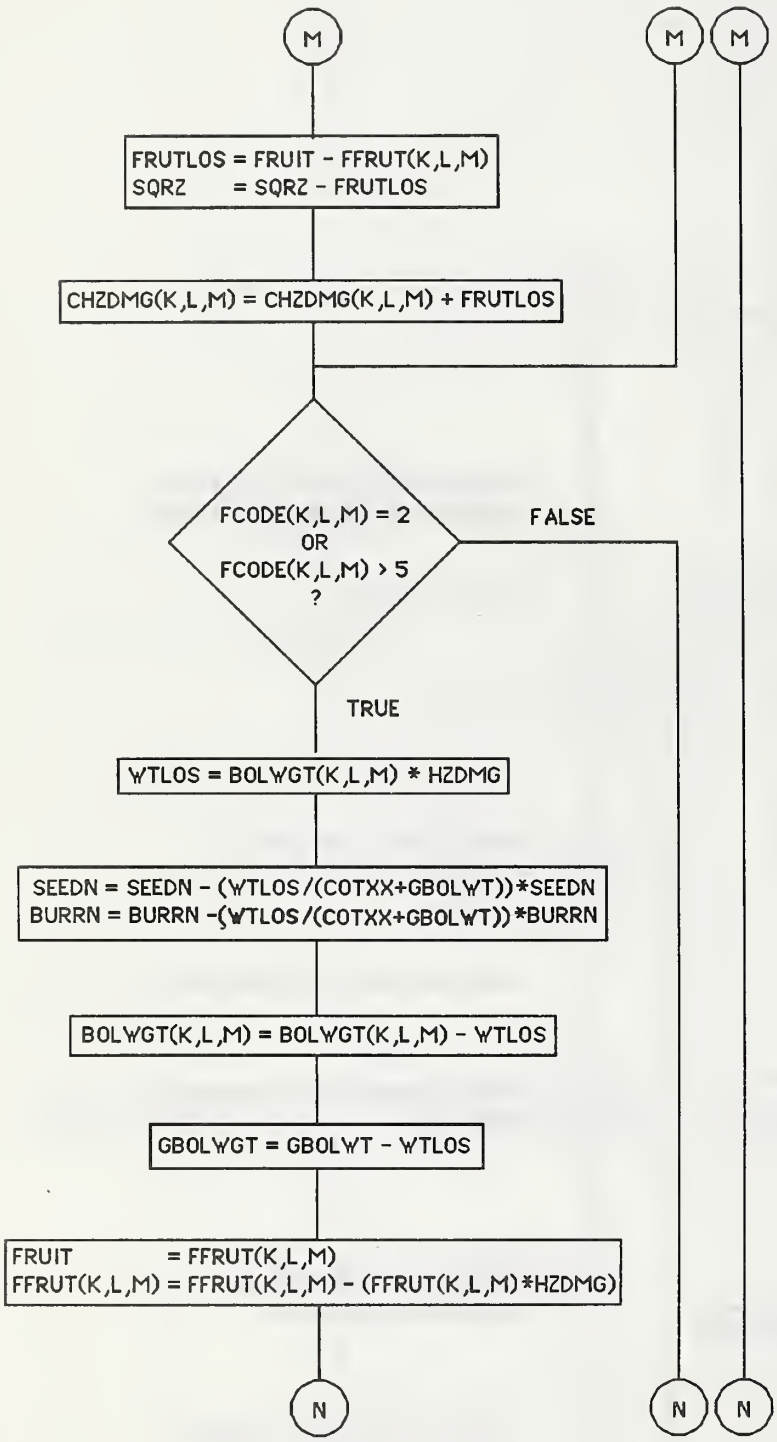
Is fruit a square?

Square weight of this site is decreased.

Accumulate amount of weight loss.

Reduce fraction of fruit remaining at this site.

If fraction of fruit at site goes to less than 0, set it to 0.



Total number of squares on plant is decreased.

Accumulate amount of damage on each fruiting site.

Is fruit a green boll?

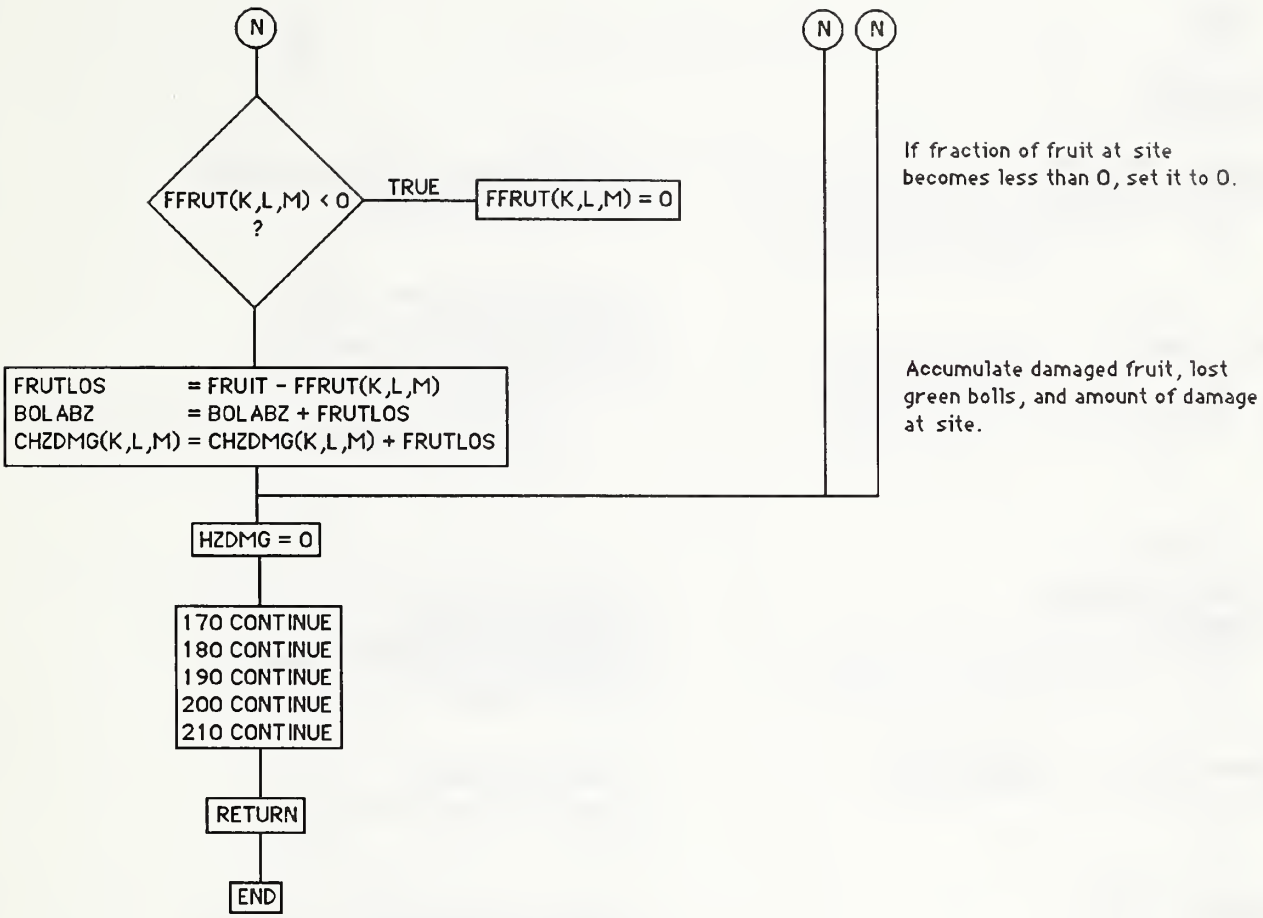
Calculate weight loss.

Reduce amount of seed and burr nitrogen.

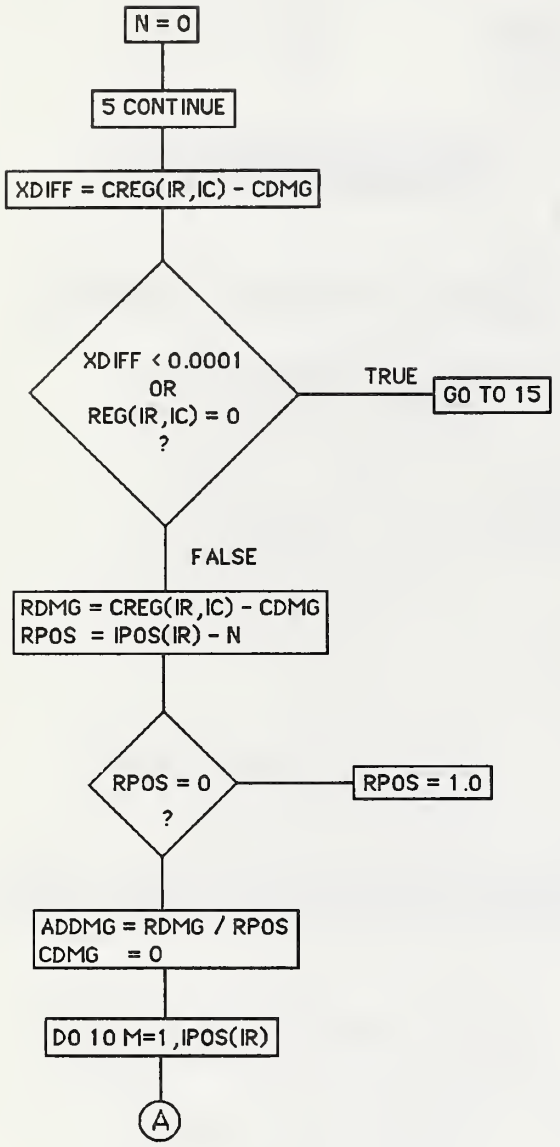
Reduce weight of green boll.

Decrease total number of green bolls on plant.

Decrease fraction of fruit at this site.


N
FFRUT(K,L,M) < 0
?
TRUE
FFRUT(K,L,M) = 0
N
N
If fraction of fruit at site becomes less than 0, set it to 0.
FRUTLOS = FRUIT - FFRUT(K,L,M)
BOLABZ = BOLABZ + FRUTLOS
CHZDMG(K,L,M) = CHZDMG(K,L,M) + FRUTLOS
Accumulate damaged fruit, lost green bolls, and amount of damage at site.
HZDMG = 0
170 CONTINUE
180 CONTINUE
190 CONTINUE
200 CONTINUE
210 CONTINUE
RETURN
END

REDIST



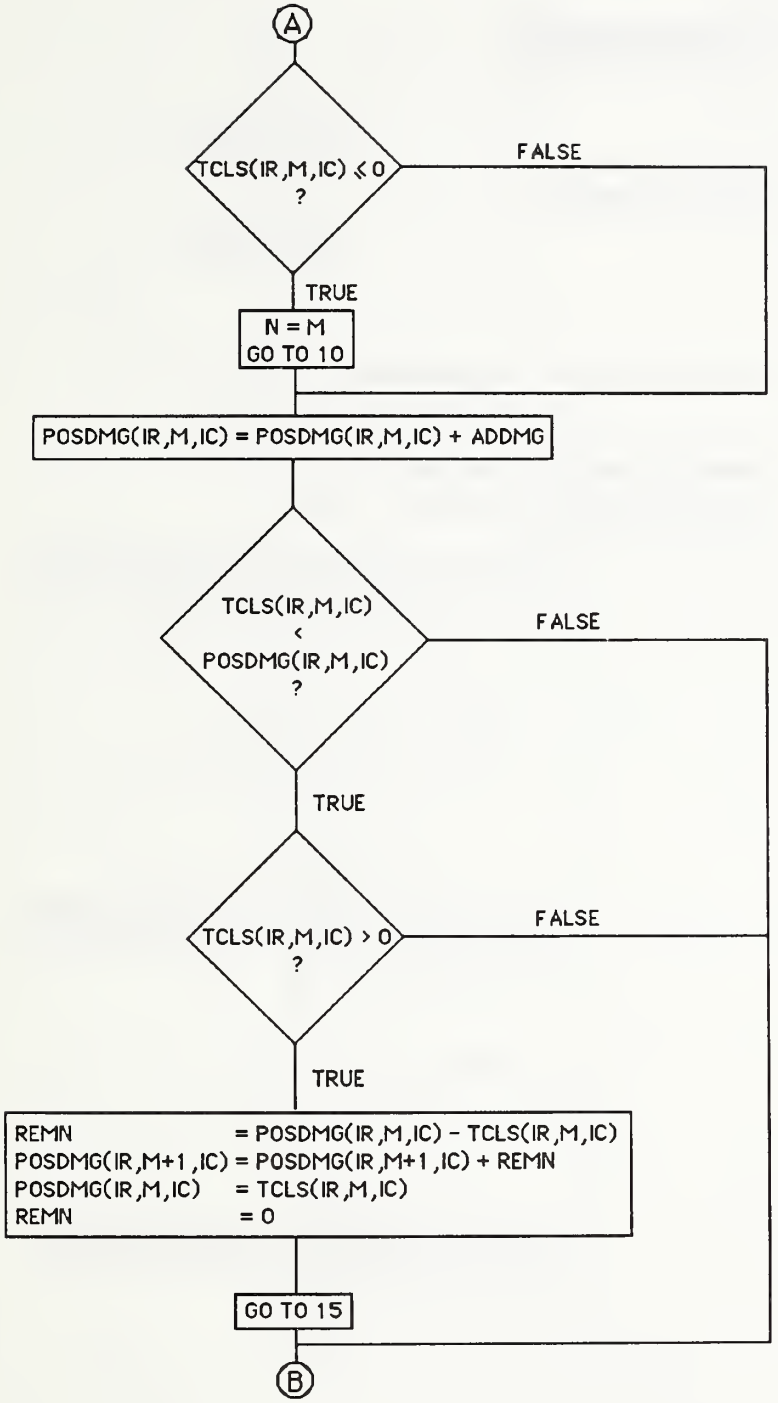
Calculate fruit remaining to be damaged within region.

If difference is less than 0.0001 or no fruit is of this age class in this region, skip rest of logic.

Subtract number to be damaged from number already marked for damage, and calculate remaining positions in region.

If remaining positions become 0, then set it at 1.0.

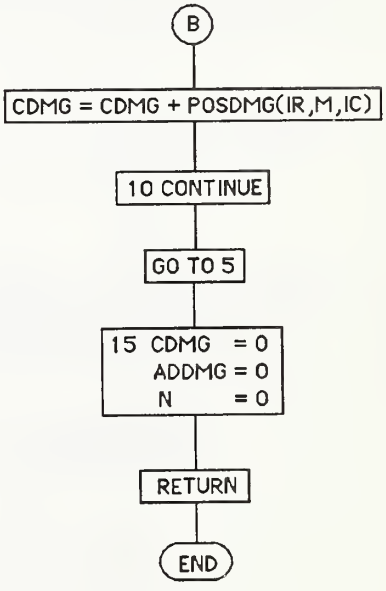
Calculate proportion to be damaged per position.



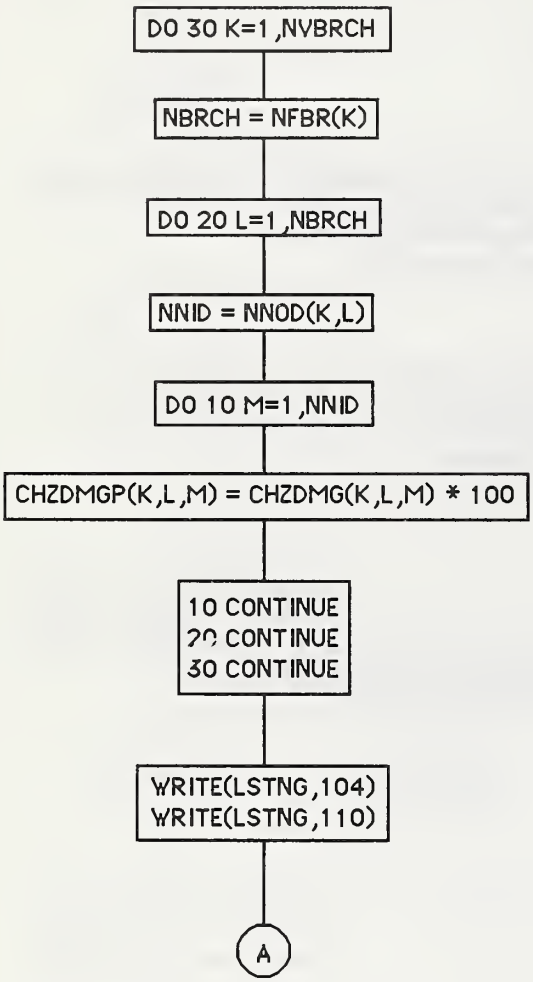
If no fruit is of this age class at this position, then set N equal to last position with fruit of this age class.

Calculate number of fruit to be damaged at this position.

If number available to be damaged is less than number to be damaged, then mark all this fruit for damage.



FRMTRX

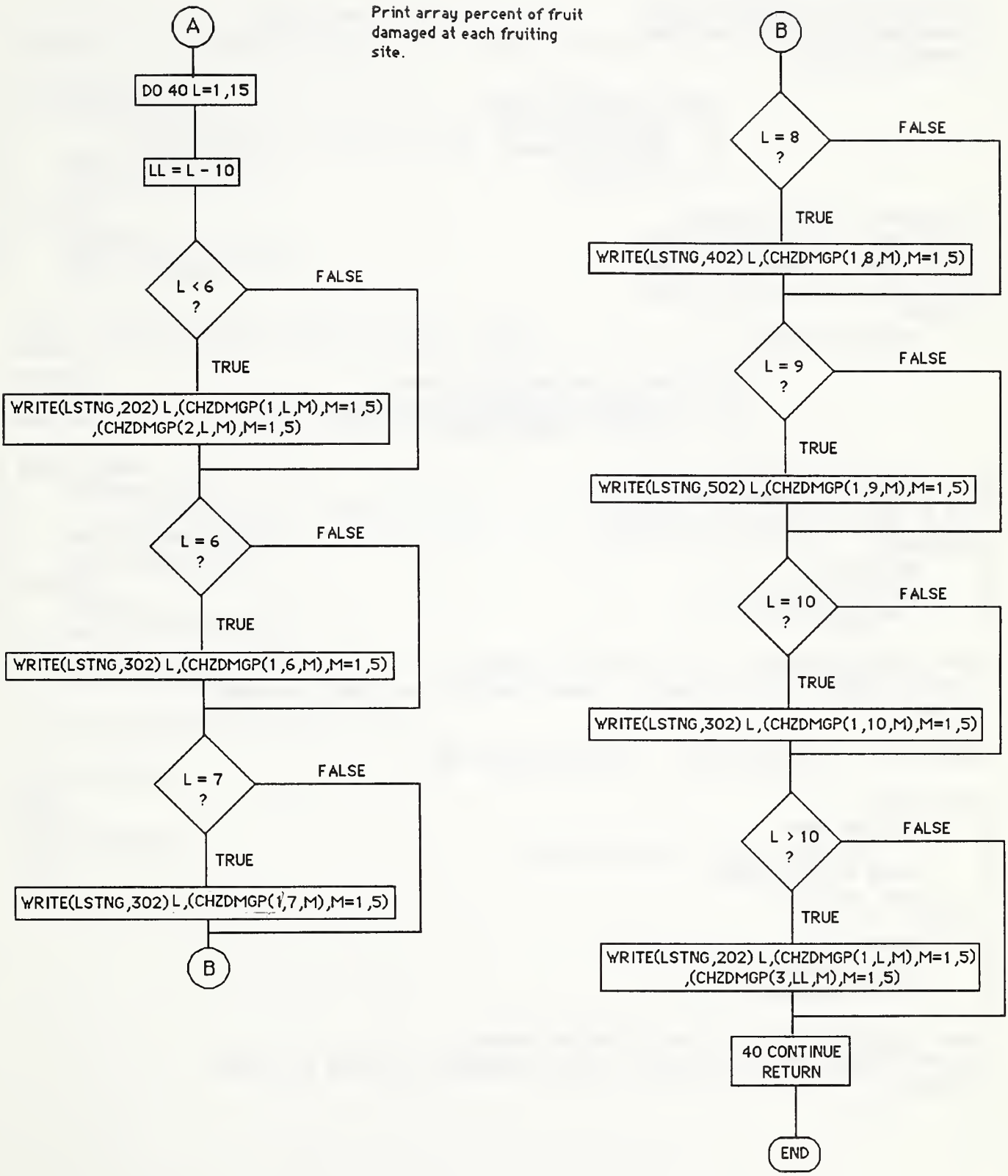


For each monopodium :

For each sympodium :

For each fruiting site on sympodium :

Convert proportion of fruit damaged at this fruiting site to a percent.


Print array percent of fruit damaged at each fruiting site.
A
DO 40 L=1,15
LL = L - 10
L < 6 ?
FALSE
TRUE
WRITE(LSTNG,202) L,(CHZDMGP(1,L,M),M=1,5) ,(CHZDMGP(2,L,M),M=1,5)
L = 6 ?
FALSE
TRUE
WRITE(LSTNG,302) L,(CHZDMGP(1,6,M),M=1,5)
L = 7 ?
FALSE
TRUE
WRITE(LSTNG,302) L,(CHZDMGP(1,7,M),M=1,5)
B
B
L = 8 ?
FALSE
TRUE
WRITE(LSTNG,402) L,(CHZDMGP(1,8,M),M=1,5)
L = 9 ?
FALSE
TRUE
WRITE(LSTNG,502) L,(CHZDMGP(1,9,M),M=1,5)
L = 10 ?
FALSE
TRUE
WRITE(LSTNG,302) L,(CHZDMGP(1,10,M),M=1,5)
L > 10 ?
FALSE
TRUE
WRITE(LSTNG,202) L,(CHZDMGP(1,L,M),M=1,5) ,(CHZDMGP(3,LL,M),M=1,5)
40 CONTINUE
RETURN
END

Command Procedure INMENU

```
$ ON CONTROL_Y THEN GOTO END2
$ OPEN/WRITE OUTFILE INPUT.DMG
$ TYPE SYS$INPUT

                        Input Heliothis data
                        1.  Heliothis model
                        2.  Scouting report
                        3.  No damage

$ INQUIRE A "SELECT NUMBER"
$ IF A .EQS. 1 THEN GOTO MODEL
$ IF A .EQS. 2 THEN GOTO SCOUT
$ IF A .EQS. 3 THEN GOTO NODMG
$ MODEL:
$     TYPE SYS$INPUT

                      Input data from Heliothis model
                      A.  Enter data from Heliothis model
                      B.  Enter data from MOTHZV

$     INQUIRE A "SELECT LETTER"
$ IF A .EQS. "A" THEN GOTO HELMODEL
$ IF A .EQS. "B" THEN GOTO MOTHZV
$ HELMODEL:
$     OPTION = 1
$     WRITE OUTFILE OPTION
$     TYPE SYS$INPUT

 Enter Heliothis data in the following format
 (leave 1 space between numbers - press [RETURN] on blank line when
finished)

 YEAR DAY      NUMBER/ACRE     PHYSIOLOGICAL AGE

$ HEL_LOOP:
$     INQUIRE DATA
$          IF DATA .EQS. "" THEN GOTO END
$     WRITE OUTFILE DATA
$     GOTO HEL_LOOP
$ MOTHZV:
$     OPTION = 2
$     WRITE OUTFILE OPTION
$     TYPE SYS$INPUT

 Enter Heliothis data in the following format
 (leave 1 space between numbers - press [RETURN] on blank line when
finished)
```

```
                    NUMBER FRUIT DAMAGED/ACRE BY
 YEAR DAY           SMALL LARVAE          LARGE LARVAE

$ MOTH_LOOP:
$     INQUIRE DATA
$          IF DATA .EQS. "" THEN GOTO END
$     WRITE OUTFILE DATA
$     GOTO MOTH_LOOP
$ SCOUT:
$     OPTION = 3
$     WRITE OUTFILE OPTION
$     TYPE SYS$INPUT

 Enter scouting report in the following format
 (leave 1 space between numbers - press [RETURN] on blank line when
finished)

 YEAR DAY          % SQUARE DAMAGE          % BOLL DAMAGE

$ SCOUT_LOOP:
$     INQUIRE DATA
$          IF DATA .EQS. "" THEN GOTO END
$     WRITE OUTFILE DATA
$     GOTO SCOUT_LOOP
$ NODMG:
$     OPTION = 4
$     WRITE OUTFILE OPTION
$ END:
$     TYPE SYS$INPUT

 The file INPUT.DMG has been created

$ CLOSE OUTFILE
$ EXIT
$ END2:
$ CLOSE OUTFILE
$ EXIT
```

Subroutine RDDMG

```
      SUBROUTINE RDDMG
C **********************
C *  READS DAMAGE FILE *
C **********************
C
      INCLUDE 'GOSCOM.FOR'
C
      LOGICAL BUGGY
C
      BUGGY = .FALSE.
      HZBUG = Ø
C
      REWIND (5Ø)
C INPUT HELIOTHIS DATA
      READ(5Ø,*) IOPTION
      IF(IOPTION.EQ.1) THEN
 1Ø     READ(5Ø,*,END=15) IBUGDAY,NUM,BUGAGE
        IF((IBUGDAY-EMERGE).EQ.IDAY) THEN
          HZBUG = NUM * (Ø.Ø35 + (Ø.Ø93 * BUGAGE))
          IF(HZBUG.LT.Ø) HZBUG=Ø
          IF(BUGAGE.LE.3) NSTR=1
          IF(BUGAGE.GT.3.AND.BUGAGE.LE.4.59) NSTR=2
          IF(BUGAGE.GT.4.59.AND.BUGAGE.LE.6.79) NSTR=3
          IF(BUGAGE.GT.6.79.AND.BUGAGE.LE.8.75) NSTR=4
          IF(BUGAGE.GT.8.75) NSTR=5
          BUGGY = .TRUE.
          CALL PREDMG
        END IF
        GO TO 1Ø
      END IF
C ENTER DATA FROM MOTHZV
      IF(IOPTION.EQ.2) THEN
 11     READ(5Ø,*,END=15) IBUGDAY, DMGSML, DMGLRGE
        IF((IBUGDAY-EMERGE).EQ.IDAY) THEN
          IF(DMGSML.GT.Ø) THEN
            NSTR = 1
            HZBUG = DMGSML
            CALL PREDMG
            BUGGY = .TRUE.
          END IF
          IF(DMGLRGE.GT.Ø) THEN
            NSTR = 2
            HZBUG = DMGLRGE
            CALL PREDMG
            BUGGY = .TRUE.
          END IF
        END IF
        GO TO 11
      END IF
```

```
 15   IF(BUGGY) CALL DAMAGE
C ENTER SCOUTING REPORT DATA
      IF(IOPTION.EQ.3) THEN
 25     READ(5Ø,*,END=3Ø) IBUGDAY,SQP,GBP
        IF((IBUGDAY-EMERGE).EQ.IDAY) THEN
          IF(SQP.GT.Ø.OR.GBP.GT.Ø) CALL PREDMG
          CALL DAMAGE
        END IF
        GO TO 25
      END IF
 3Ø   RETURN
      END
```

Subroutine PREDMG

```
      SUBROUTINE PREDMG
C *******************************************************
C * DISTRIBUTES NUMBER OF DAMAGED FRUIT ACROSS AGE      *
C * CLASSES OF FRUIT.  DISTRIBUTION OF DAMAGE IS BASED  *
C * ON INFORMATION FROM Wilson, L.T., and A.P. Gutierrez*
C * Fruit predation submodel: Heliothis larvae feeding  *
C * upon cotton fruiting structures.                    *
C * Hilgardia 48(2):24-36,  1980                        *
C *******************************************************
C
      INCLUDE 'GOSCOM.FOR'
C
      REAL NUM
      DIMENSION PROP(7),PDMG(5,7),PREF(5,7),STRAT(5,7)
      DIMENSION PREFA(2,7), STRATA(2,7), TCLASS(7)
      DATA PREF/.6693,.531,.3855,.105,.0172,1,1,.8733,.5641,
     & .3287,.4124,.4071,.7412,.8409,.6701,0,0,1,1,1,0,0,
     & .4119,.3801,.6018,0,0,0,.3783,.6987,0,0,0,0,.5498/
      DATA STRAT/1,1,.7014,.479,.2068,.6485,.9839,1,1,.5064,
     & .2876,.4894,.6132,.9086,.5719,0,0,.2458,.9569,1,0,0,.0884,
     & .2314,.1944,0,0,0,.1004,.14,0,0,0,0,.031/
      DATA PREFA/.5286,.0611,.9578,.4464,.5202,.7555,.3333,1.0,
     & .1373,.491,0,.5385,0,.2749/
      DATA STRATA/.9005,.3429,.8775,.7532,.4634,.7403,.0819,.983,
     & .0295,.2129,0,.1202,0,.0155/
C SET COUNTERS TO 0
C
      SFRUIT=0
      TOTSQR = 0
      TOTGB = 0
      DENOM = 0
      DO 30  I=1,7
        DO 20 J=1,5
          TCLASS(I) = 0
          PDMG(J,I) = 0
 20     CONTINUE
 30   CONTINUE
C
C IF DAMAGE IS TO OCCUR TODAY, CLASSIFY FRUIT AND CALCULATE
C PROPORTION OF EACH FRUIT CLASS.
C
C            CLASS          DESCRIPTION
C            ************************
C            1        SMALL SQUARE
C            2        MEDIUM SQUARE
C            3        LARGE SQUARE
C            4        FLOWER
C            5        SMALL GREEN BOLL
C            6        MEDIUM GREEN BOLL
C            7        LARGE GREEN BOLL
```

```
C
      DO 60 K=1,3
        DO 50 L=1,30
          DO 40 M=1,5
            CLASS(K,L,M) = 0
            IF(FFRUT(K,L,M).LE.0) GO TO 40
            IF(AGE(K,L,M).LT.2.OR.AGE(K,L,M).GT.48) GO TO 40
            IF(FCODE(K,L,M).EQ.2.OR.FCODE(K,L,M).GT.5) THEN
              IF(AGEBOL(K,L,M).LT.3) CLASS(K,L,M)=4
              IF(AGEBOL(K,L,M).GE.3.AND.AGEBOL(K,L,M).LT.10)
     &          CLASS(K,L,M)=5
              IF(AGEBOL(K,L,M).GE.10.AND.AGEBOL(K,L,M).LT.17)
     &          CLASS(K,L,M)=6
              IF(AGEBOL(K,L,M).GE.17)
     &          CLASS(K,L,M)=7
            END IF
            IF(FCODE(K,L,M).EQ.1.OR.FCODE(K,L,M).EQ.5) THEN
              IF(AGE(K,L,M).GE.2.AND.AGE(K,L,M).LE.8)
     &          CLASS(K,L,M)=1
              IF(AGE(K,L,M).GE.9.AND.AGE(K,L,M).LE.16)
     &          CLASS(K,L,M)=2
              IF(AGE(K,L,M).GE.17) CLASS(K,L,M)=3
            END IF
            IF(CLASS(K,L,M).GT.0) THEN
              SFRUIT = SFRUIT + FFRUT(K,L,M)
              IC = CLASS(K,L,M)
              TCLASS(IC) = TCLASS(IC) + FFRUT(K,L,M)
              IF(IC.LE.3) TOTSQR = TOTSQR + FFRUT(K,L,M)
              IF(IC.GE.4) TOTGB  = TOTGB + FFRUT(K,L,M)
            END IF
 40       CONTINUE
 50     CONTINUE
 60   CONTINUE
C
C OPTION = 1; INPUT NUMBER OF FRUIT DAMAGED BY EACH INSTAR
C
*********************************************************************
* VARIABLES:                                                        *
*                                                                   *
* PREF(instar,fruit class)  = larval food preference values for     *
*                             various age fruits.                   *
* PROP(fruit class)         = proportion of each age class.         *
* STRAT(instar,fruit class) = age specific larval stratification    *
*                             coefficients.                         *
* PDMG(instar,fruit class)  = proportion of damage occurring on each*
*                             fruit age class by each instar.       *
* HZBUG                     = number of larvae/acre.                *
* NSTR                      = instar.                               *
```

```
* SMLARV(fruit class)       = number of fruit of each age class/acre  *
*                             damaged by larvae from instar 1-3.      *
* LGLARV(fruit class)       = number of fruit of each age class/acre  *
*                             damaged by larvae from instar 4-5.      *
*************************************************************************
C
      IF(IOPTION.EQ.1) THEN
        DO 70 I=1,7
          IF(SFRUIT.LE.0) RETURN
          PROP(I) = TCLASS(I) / SFRUIT
 70     CONTINUE
        DO 80 I=1,7
 80     DENOM = PROP(I)*PREF(NSTR,I)*STRAT(NSTR,I) + DENOM
        DO 90 I=1,7
          IF(DENOM.GT.0) THEN
            PDMG(NSTR,I)=(PROP(I)*PREF(NSTR,I)*STRAT(NSTR,I))/DENOM
          END IF
 90     CONTINUE
        DO 100 I=1,7
          IF(NSTR.LE.3) THEN
            SMLARV(I) = HZBUG*PDMG(NSTR,I)+SMLARV(I)
          ELSE
            LGLARV(I) = HZBUG*PDMG(NSTR,I)+LGLARV(I)
          END IF
 100    CONTINUE
      END IF
C
C IOPTION = 2; INPUT DATA FROM MOTHZV
C
      IF(IOPTION.EQ.2) THEN
        DO 110 I=1,7
          IF(SFRUIT.LE.0) RETURN
          PROP(I) = TCLASS(I) / SFRUIT
110     CONTINUE
        DO 120 I=1,7
120     DENOM = PROP(I)*PREFA(NSTR,I)*STRATA(NSTR,I)+DENOM
        DO 130 I=1,7
          IF(DENOM.GT.0) THEN
            PDMG(NSTR,I)=(PROP(I)*PREFA(NSTR,I)*STRATA(NSTR,I))/DENOM
          END IF
130     CONTINUE
        DO 140 I=1,7
          IF(NSTR.EQ.1) THEN
            SMLARV(I) = HZBUG*PDMG(NSTR,I)+SMLARV(I)
          ELSE
            LGLARV(I) = HZBUG*PDMG(NSTR,I)+LGLARV(I)
          END IF
140     CONTINUE
      END IF
```

```
C
C IOPTION = 3; INPUT PERCENT OF SQUARES AND/OR GREEN BOLLS DAMAGED PER
ACRE
C
C NUMBER OF FRUIT OF EACH AGE CLASS TO BE DAMAGED IS DIRECTLY
C PROPORTIONAL TO NUMBER OF EACH AGE CLASS PRESENT.
C
      IF(IOPTION.EQ.3) THEN
        IF(SQP.GT.0) THEN
          DO 150 I=1,3
 150      IF(TOTSQR.GT.0) PROP(I) = TCLASS(I) / TOTSQR
          NUM = TOTSQR*(SQP/100)*POPPLT
          DO 160 I=1,3
 160      FRUTDMG(I) = PROP(I)*NUM
        END IF
        IF(GBP.GT.0) THEN
          DO 170 I=4,7
 170      IF(TOTGB.GT.0) PROP(I) = TCLASS(I) / TOTGB
          NUM = TOTGB*(GBP/100)*POPPLT
          DO 180 I=4,7
 180      FRUTDMG(I) = PROP(I)*NUM
        END IF
      END IF
      RETURN
      END
```

Subroutine DAMAGE

```
C ***********************************************************************
C *                                                                     *
C *               DAMAGE SUBROUTINE                                     *
C *                                                                     *
C * THIS SUBROUTINE DISTRIBUTES DAMAGE CAUSED BY HELIOTHIS              *
C * FEEDING.                                                            *
C *                                                                     *
C ***********************************************************************
C
      INCLUDE 'GOSCOM.FOR'
      DIMENSION BPER(5), DTOTAL(7), VEG(7), BUGDMG(7), VDMG(7),
     &          REGDMG(4,7), BEGIN(4), END(4), DMG(7)
      INTEGER UPPER
C
      DATA IPOS/0,0,0,5/
      DATA BPER/.54,.23,.12,.055,.055/
C
C SET ALL COUNTERS TO 0
C
      SFRUIT      = 0
      ACTDMG      = 0
      CDMG        = 0
      REMN        = 0
      REMAIN      = 0
      ADDMG       = 0
      FRUTLOS     = 0
      HELIOTHIS   = 0
      PVEG        = 0
      VEGP        = 0
C
      DO 30 I=1,7
        DO 20 K=1,4
          DO 10 L=1,5
            DTOTAL(I)      = 0
            VEG(I)         = 0
            BUGDMG(I)      = 0
            VDMG(I)        = 0
            REG(K,I)       = 0
            CREG(K,I)      = 0
            REGDMG(K,I)    = 0
            TCLS(K,L,I)    = 0
            POSDMG(K,L,I)  = 0
 10       CONTINUE
 20     CONTINUE
 30   CONTINUE
C
C DIVIDE PLANT INTO THIRDS.  TOP 1/3 OF PLANT IS REGION 1, MIDDLE 1/3 IS
C REGION 2, AND LOWER 1/3 IS REGION 3.  REGION 4 IS VEGETATIVE STEM.
C BOTH VEGETATIVE STEMS ARE GROUPED UNDER REGION 4.
```

```
C
      LOWER = NFBR(1) / 3.Ø
      MID   = LOWER * 2.Ø
      UPPER = NFBR(1)
C
C COUNT TOTAL NUMBER OF POSITIONS/REGION.
C COUNT NUMBER OF FRUIT/AGE CLASS ON MAIN AND VEGETATIVE STEMS.
C COUNT NUMBER OF FRUIT/AGE CLASS/REGION.
C COUNT NUMBER OF FRUIT/AGE CLASS/REGION/POSITION.
C
*****************************************************************
* VARIABLES:                                                    *
*                                                               *
* SFRUIT           = # fruit susceptible for damage.            *
* CLASS(K,L,M)     = Age class of fruit.                        *
*                    1 = 1-8    4 = 25-26    7 = 41-48         *
*                    2 = 9-16   5 = 27-33                      *
*                    3 = 17-24  6 = 34-40                      *
* IPOS(IR)         = Max. # of positions/region.                *
* DTOTAL(CLASS)    = # of fruit/age class on mainstem.          *
* VEG(CLASS)       = # of fruit/age class on veg. stems.        *
* REG(IR,CLASS)    = # of fruit/age class/region.               *
* TCLS(IR,M,CLASS) = # of fruit/region/position/age class.      *
*****************************************************************
C
      DO 7Ø K=1,3
        IF(K.EQ.1) THEN
          ISTART = 1
          IEND   = 3
        ELSE
          ISTART = 4
          IEND   = 4
        END IF
        DO 6Ø IR=ISTART,IEND
          IF(IR.EQ.1) THEN
            BEGIN(IR) = MID + 1
            END(IR)     = UPPER
          END IF
          IF(IR.EQ.2) THEN
            BEGIN(IR) = LOWER + 1
            END(IR)     = MID
          END IF
          IF(IR.EQ.3) THEN
            BEGIN(IR) = 1
            END(IR)     = LOWER
          END IF
          IF(IR.EQ.4) THEN
            BEGIN(IR) = 1
            END(IR)     = 3Ø
```

```
          END IF
          DO 50 L=BEGIN(IR),END(IR)
            IF(BEGIN(IR).EQ.0) GO TO 70
            DO 40 M=1,5
              IF(CLASS(K,L,M).LE.0) GO TO 40
              ICLS = CLASS(K,L,M)
              IF(K.EQ.1) THEN
                DTOTAL(ICLS) = DTOTAL(ICLS) + FFRUT(K,L,M)
                IF(M.GT.IPOS(IR)) IPOS(IR) = M
              ELSE
                VEG(ICLS) = VEG(ICLS) + FFRUT(K,L,M)
                IPOS(IR) = 5
              END IF
              REG(IR,ICLS) = REG(IR,ICLS) + FFRUT(K,L,M)
              TCLS(IR,M,ICLS) = TCLS(IR,M,ICLS) + FFRUT(K,L,M)
              SFRUIT = SFRUIT + FFRUT(K,L,M)
 40         CONTINUE
 50       CONTINUE
 60     CONTINUE
 70   CONTINUE
C
C CONVERT NUMBER OF FRUIT TO BE DAMAGED TO PER PLANT BASIS.
C WEIGHT VERTICAL DISTRIBUTION OF DAMAGE BASED ON AGE OF LARVA.
C     Ramalho, F.S., et al., 1984, J. Econ. Ent. 77:591-594.
C
*************************************************************************
* VARIABLES:
*
*
* SMLARV(CLASS)    = # of fruit/age small larvae to be damaged today.
* LGLARV(CLASS)    = # of fruit/age large larvae to be damaged today.
* FRUTDMG(CLASS)   = # of fruit/age damaged today.
* PLTDMG           = # of fruit to be damaged per plant.
* CREG(IR,CLASS)   = # fruit to be damaged/region/age class.
* BUGDMG(CLASS)    = # of fruit to be damaged/age class.
* PVEG             = Proportion of fruit of each age class on veg. stem.
* VEGP             = Proportion of fruit of each age class on mainstem.
*************************************************************************
C
      DO 80 ICLS=1,7
        IF(DTOTAL(ICLS).GT.0.) THEN
          PVEG = VEG(ICLS) / (DTOTAL(ICLS) + VEG(ICLS))
        ELSE
          PVEG = 0
        END IF
        VEGP = 1 - PVEG
        IF(SMLARV(ICLS).GT.0) THEN
          PLTDMG = SMLARV(ICLS) / POPPLT
          CREG(1,ICLS) = CREG(1,ICLS) + (PLTDMG * 0.50) * VEGP
```

```
          CREG(2,ICLS) = CREG(2,ICLS) + (PLTDMG * Ø.37) * VEGP
          CREG(3,ICLS) = CREG(3,ICLS) + (PLTDMG * Ø.13) * VEGP
          CREG(4,ICLS) = PLTDMG * PVEG
        END IF
        IF(LGLARV(ICLS).GT.Ø) THEN
          PLTDMG = LGLARV(ICLS) / POPPLT
          CREG(1,ICLS) = CREG(1,ICLS) + (PLTDMG * Ø.39) * VEGP
          CREG(2,ICLS) = CREG(2,ICLS) + (PLTDMG * Ø.43) * VEGP
          CREG(3,ICLS) = CREG(3,ICLS) + (PLTDMG * Ø.18) * VEGP
          CREG(4,ICLS) = PLTDMG * PVEG
        END IF
        IF(FRUTDMG(ICLS).GT.Ø) THEN
          PLTDMG = FRUTDMG(ICLS) / POPPLT
          CREG(1,ICLS) = CREG(1,ICLS) + (PLTDMG * Ø.45) * VEGP
          CREG(2,ICLS) = CREG(2,ICLS) + (PLTDMG * Ø.40) * VEGP
          CREG(3,ICLS) = CREG(3,ICLS) + (PLTDMG * Ø.15) * VEGP
          CREG(4,ICLS) = PLTDMG * PVEG
        END IF
        BUGDMG(ICLS) = BUGDMG(ICLS) + CREG(1,ICLS)
        BUGDMG(ICLS) = BUGDMG(ICLS) + CREG(2,ICLS)
        BUGDMG(ICLS) = BUGDMG(ICLS) + CREG(3,ICLS)
        SMLARV(ICLS) = Ø
        LGLARV(ICLS) = Ø
        FRUTDMG(ICLS) = Ø
 8Ø   CONTINUE
C
C COMPARE NUMBER OF EACH AGE CLASS PRESENT TO NUMBER OF
C EACH AGE CLASS TO BE DAMAGED TODAY.
C
*********************************************************************
* VARIABLES:
*
* CDMG            = Cumulate today's damage.
* POSDMG(IR,M,IC) = # fruit to be damaged/region/position/age class.
* BPER(M)         = % of damage occurring/position.
* REMN            = # fruit left over to be damaged to be added
*                   to next position.
*********************************************************************
C
      DO 12Ø IC=1,7
C
C COMPARE TOTAL NUMBER OF FRUIT TO BE DAMAGED/AGE CLASS WITH TOTAL
C NUMBER AVAILABLE.  IF NUMBER OF FRUIT AVAILABLE OF THAT AGE CLASS IS
C LESS THAN OR EQUAL TO NUMBER TO BE DAMAGED, THEN REMOVE ALL THIS
C FRUIT.
C ADD REMAINDER TO VEGETATIVE STEMS.
C
        IF(BUGDMG(IC).EQ.Ø) GO TO 12Ø
        IF(DTOTAL(IC).LE.BUGDMG(IC)) THEN
```

```
          DMG(IC) = 1.Ø
          CREG(4,IC) = BUGDMG(IC) - DTOTAL(IC) + CREG(4,IC)
        ELSE
C
C COMPARE NUMBER OF FRUIT/AGE CLASS/REGION AVAILABLE WITH NUMBER OF
C FRUIT/AGE CLASS/REGION TO DAMAGE.  IF LESS FRUIT IS AVAILABLE
C THAN NEEDS TO BE DAMAGED, THEN REMOVE ALL FRUIT OF THAT AGE CLASS FROM
C REGION AND ADD REMAINDER TO NEXT REGION.
C
          DO 11Ø IR=1,3
            IF(REG(IR,IC).LE.Ø) THEN
              CREG(IR+1,IC) = CREG(IR+1,IC) + CREG(IR,IC)
              GO TO 11Ø
            END IF
            IF(REG(IR,IC).LE.CREG(IR,IC)) THEN
              REGDMG(IR,IC) = 1.Ø
              CREG(IR+1,IC)=CREG(IR+1,IC)+(CREG(IR,IC) - REG(IR,IC))
              CDMG = REG(IR,IC)
              GO TO 11Ø
            ELSE
C
C IF NUMBER OF FRUIT AVAILABLE IS GREATER THAN NUMBER TO BE DAMAGED,
C THEN EVALUATE EACH FRUIT ON PLANT AND CALCULATE AMOUNT OF FRUIT
C TO REMOVE PER FRUITING SITE.
C
              CDMG = Ø
              K=1
              DO 1ØØ M=1,IPOS(IR)
                IF(BEGIN(IR).EQ.Ø) GO TO 11Ø
                DO 9Ø L=BEGIN(IR),END(IR)
C
C WEIGHT HORIZONTAL DISTRIBUTION OF DAMAGE BASED ON POSITION ON FRUITING
C BRANCH.
C     54% POSITION 1     5.5% POSITION 4
C     23% POSITION 2     5.5% POSITION 5
C     12% POSITION 3
C   Ramalho, F.S., et al.,  1984,  J. Econ. Ent. 77:591-594
C
                  IF(CLASS(K,L,M).EQ.IC.AND.BUGDMG(IC).GT.Ø) THEN
                    POSDMG(IR,M,IC) = CREG(IR,IC) * BPER(M)
C
C IF NUMBER OF FRUIT AVAILABLE IS LESS THAN OR EQUAL TO NUMBER TO BE
C DAMAGED, THEN MOVE REMAINDER TO BE DAMAGED TO NEXT POSITION ON THAT
C FRUITING BRANCH.
C
                    IF(TCLS(IR,M,IC).LE.POSDMG(IR,M,IC)) THEN
                      IF(TCLS(IR,M+1,IC).GT.Ø) THEN
                        REMN = POSDMG(IR,M,IC) - TCLS(IR,M,IC)
                        POSDMG(IR,M+1,IC) = POSDMG(IR,M+1,IC) + REMN
```

```
                        POSDMG(IR,M,IC) = TCLS(IR,M,IC)
                      END IF
                    END IF
                  END IF
 90               CONTINUE
                  CDMG = CDMG + POSDMG(IR,M,IC)
 100            CONTINUE
              END IF
C
C IF NOT ENOUGH FRUIT HAS BEEN DAMAGED WITHIN THAT REGION, THEN
C REDISTRIBUTE REMAINDER EVENLY.
C
              IF(CDMG.LT.CREG(IR,IC)) CALL REDIST
 110        CONTINUE
          END IF
 120    CONTINUE
C
C DETERMINE NUMBER TO BE DAMAGED ON VEG STEM.
C IF AMOUNT OF FRUIT AVAILABLE TO BE DAMAGED IS LESS THAN NUMBER TO BE
C DAMAGED,THEN REMOVE ALL FRUIT OF THAT AGE CLASS AND STORE REMAINDER.
C IF THERE IS ENOUGH FRUIT AVAILABLE, THEN CALCULATE PERCENT TO BE
C REMOVED FROM EACH FRUITING SITE.
C
        DO 130 IC=1,7
          IF(VEG(IC).GT.0.0.OR.CREG(4,IC).GT.0.0) THEN
            IF(CREG(4,IC).GE.VEG(IC)) THEN
              VDMG(IC) = 1.0
              REMAIN = REMAIN + (CREG(4,IC) - VEG(IC))
            ELSE
              VDMG(IC) = CREG(4,IC) / VEG(IC)
            END IF
          ELSE
            REMAIN = REMAIN + CREG(4,IC)
          END IF
 130    CONTINUE
C
C COUNT ACTUAL NUMBER OF FRUIT DAMAGED TODAY.
C
* ACTDMG = # fruit actually damaged today.
C
        DO 160 IR=1,4
          DO 150 M=1,IPOS(IR)
            DO 140 IC=1,7
              ACTDMG = ACTDMG + POSDMG(IR,M,IC)
 140        CONTINUE
 150      CONTINUE
 160    CONTINUE
C
C IF ANY FRUIT IS LEFT OVER TO BE DAMAGED AND NUMBER TO BE DAMAGED IS
```

```
C NOT EQUAL TO NUMBER OF SUSCEPTIBLE FRUIT ON PLANT, THEN
C REDISTRIBUTE REMAINDER TO REST OF FRUIT.
C
* ADDMG = # fruit to be damaged to add to each fruiting site.
C
      IF(REMAIN.GT.0.AND.SFRUIT.NE.ACTDMG) THEN
        ADDMG = REMAIN / (SFRUIT - ACTDMG)
      END IF
C
      DO 210 K=1,3
        IF(K.EQ.1) THEN
          ISTART = 1
          IEND = 3
        ELSE
          ISTART = 4
          IEND = 4
        END IF
        DO 200 IR=ISTART,IEND
          IF(BEGIN(IR).EQ.0) GO TO 210
          DO 190 L=BEGIN(IR),END(IR)
            DO 180 M=1,IPOS(IR)
              IF(FRUT(K,L,M).LE.0) GO TO 180
C
              DO 170 IC=1,7
                IF(CLASS(K,L,M).NE.IC) GO TO 170
C
C CALCULATE AMOUNT OF ABSCISSION.
C
*************************************************************************
* VARIABLES:                                                            *
*                                                                       *
* HZDMG         = % to remove from site due to Heliothis damage.        *
* VDMG(IC)      = # fruit to be damaged/age class on veg. stems.         *
*************************************************************************
C
                IF(K.EQ.1) THEN
                  IF(DMG(IC).EQ.1.0) THEN
                    HZDMG = 1.0
                    GO TO 175
                  END IF
                  IF(REGDMG(IR,IC).EQ.1.0) THEN
                    HZDMG = 1.0
                    GO TO 175
                  END IF
                  IF(TCLS(IR,M,IC).GT.0.0) THEN
                    HZDMG = (POSDMG(IR,M,IC) / TCLS(IR,M,IC)) + ADDMG
                    IF(HZDMG.GT.1.0) HZDMG = 1.0
                  END IF
                ELSE
```

```
                HZDMG = VDMG(IC) + ADDMG
                IF(HZDMG.GT.1.Ø) HZDMG = 1.Ø
              END IF
C CALCULATE AMOUNT OF FRUIT DAMAGED PER SITE.
 175          CONTINUE
              IF(HZDMG.GT.Ø) THEN
                IF(FCODE(K,L,M).EQ.1.OR.FCODE(K,L,M).EQ.5) THEN
                  WTLOS = SQRWT(K,L,M) * HZDMG
                  SQRWT(K,L,M) = SQRWT(K,L,M) - WTLOS
                  PQFLR = PQFLR + WTLOS
                  FRUIT = FFRUT(K,L,M)
                  FFRUT(K,L,M) = FFRUT(K,L,M) - (FFRUT(K,L,M)*HZDMG)
                  IF(FFRUT(K,L,M).LT.Ø) FFRUT(K,L,M) = Ø
                  FRUTLOS = FRUIT - FFRUT(K,L,M)
                  SQRZ = SQRZ - FRUTLOS
                  CHZDMG(K,L,M) = CHZDMG(K,L,M) + FRUTLOS
                END IF
                IF(FCODE(K,L,M).EQ.2.OR.FCODE(K,L,M).GT.5) THEN
                  WTLOS =  BOLWGT(K,L,M) * HZDMG
                  SEEDN = SEEDN - (WTLOS/(COTXX+GBOLWT))*SEEDN
                  BURRN = BURRN - (WTLOS/(COTXX+GBOLWT))*BURRN
                  BOLWGT(K,L,M) = BOLWGT(K,L,M) - WTLOS
                  GBOLWT = GBOLWT - WTLOS
                  FRUIT = FFRUT(K,L,M)
                  FFRUT(K,L,M) = FFRUT(K,L,M) -(FFRUT(K,L,M)*HZDMG)
                  IF(FFRUT(K,L,M).LT.Ø) FFRUT(K,L,M) = Ø
                  FRUTLOS = FRUIT - FFRUT(K,L,M)
                  BOLABZ = BOLABZ + FRUTLOS
                  CHZDMG(K,L,M) = CHZDMG(K,L,M) + FRUTLOS
                END IF
              END IF
              HZDMG = Ø
 17Ø        CONTINUE
 18Ø      CONTINUE
 19Ø    CONTINUE
 2ØØ  CONTINUE
 21Ø  CONTINUE
      RETURN
      END
```

Subroutine REDIST

```
*****************************************************************
*                                                               *
*                     SUBROUTINE REDIST                         *
*                                                               *
* THIS SUBROUTINE REDISTRIBUTES REMAINING DAMAGE.               *
*                                                               *
*****************************************************************
C

      INCLUDE 'GOSCOM.FOR'
C
C
      N = 0
 5    CONTINUE
        XDIFF = CREG(IR,IC) - CDMG
      IF(XDIFF.LT.0.0001.OR.REG(IR,IC).EQ.0.0) GO TO 15
         RDMG = CREG(IR,IC) - CDMG
         RPOS = IPOS(IR) - N
            IF(RPOS.EQ.0.0) RPOS = 1.0
        ADDMG = RDMG / RPOS
C
         CDMG = 0.0
         DO 10 M=1,IPOS(IR)
            IF(TCLS(IR,M,IC).LE.0.0) THEN
                N = M
                GO TO 10
            END IF
            POSDMG(IR,M,IC) = POSDMG(IR,M,IC) + ADDMG
            IF(TCLS(IR,M,IC).LT.POSDMG(IR,M,IC)) THEN
               IF(TCLS(IR,M,IC).GT.0.0) THEN
                  REMN = POSDMG(IR,M,IC) - TCLS(IR,M,IC)
                  POSDMG(IR,M+1,IC) = POSDMG(IR,M+1,IC) + REMN
                  POSDMG(IR,M,IC) = TCLS(IR,M,IC)
                  REMN = 0
                  GO TO 15
               END IF
            END IF
            CDMG = CDMG + POSDMG(IR,M,IC)
 10   CONTINUE
      GO TO 5
 15   CDMG = 0
      ADDMG = 0
      N = 0
      RETURN
      END
```

Subroutine FRMTRX

```
C  ************************************************************
C  *                                                          *
C  *  THIS SUBROUTINE DISPLAYS OUTPUT OF INITIATION, BLOOM, AND *
C  *  OPEN BOLL DATE, PERCENT FRUIT AT EACH SITE, AND AMOUNT OF *
C  *  DAMAGE AT EACH SITE.  THIS IS MODIFICATION OF           *
C  *  SUBROUTINE MATURE.                                      *
C  *                                                          *
C  ************************************************************
C
       INCLUDE 'GOSCOM.FOR'
       DIMENSION CHZDMGP(3,30,5)
C
C  FORMATS
C
104    FORMAT('1',15X,'Percentage of Fruit Damaged at Each',
     .' Location',/)
110    FORMAT(15X,'Mainstem (K1)',15X,'Vegetative Branch 1 (K2)' /
     . 10X,'M1    M2    M3    M4    M5',8X,'M1    M2    M3    M4    M5')
202    FORMAT('  L',I3,5(2X,F4.0),4X,5(2X,F4.0))
302    FORMAT('  L',I3,5(2X,F4.0))
402    FORMAT('  L',I3,5(2X,F4.0),7X,'Vegetative Branch 2 (K3)')
502    FORMAT('  L',I3,5(2X,F4.0),7X,'M1    M2    M3    M4    M5')
C
C
       DO 30 K=1,NVBRCH
          NBRCH = NFBR(K)
          DO 20 L=1,NBRCH
             NNID = NNOD(K,L)
             DO 10 M=1,NNID
C  PERCENT DAMAGE
                CHZDMGP(K,L,M) = CHZDMG(K,L,M) * 100.0
 10          CONTINUE
 20       CONTINUE
 30    CONTINUE
C  PRINT PERCENT DAMAGE PER SITE
       WRITE(LSTNG,104)
       WRITE(LSTNG,110)
       DO 40 L=1,15
         LL = L-10
         IF(L.LT.6)  WRITE(LSTNG,202)L,(CHZDMGP(1,L,M) ,M=1,5)
     .                              ,(CHZDMGP(2,L,M) ,M=1,5)
         IF(L.EQ.6)  WRITE(LSTNG,302)L,(CHZDMGP(1,6,M) ,M=1,5)
         IF(L.EQ.7)  WRITE(LSTNG,302)L,(CHZDMGP(1,7,M) ,M=1,5)
         IF(L.EQ.8)  WRITE(LSTNG,402)L,(CHZDMGP(1,8,M) ,M=1,5)
         IF(L.EQ.9)  WRITE(LSTNG,502)L,(CHZDMGP(1,9,M) ,M=1,5)
         IF(L.EQ.10) WRITE(LSTNG,302)L,(CHZDMGP(1,10,M),M=1,5)
         IF(L.GT.10) WRITE(LSTNG,202)L,(CHZDMGP(1,L,M) ,M=1,5)
     .                              ,(CHZDMGP(3,LL,M),M=1,5)

 40    CONTINUE
       RETURN
       END
```

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